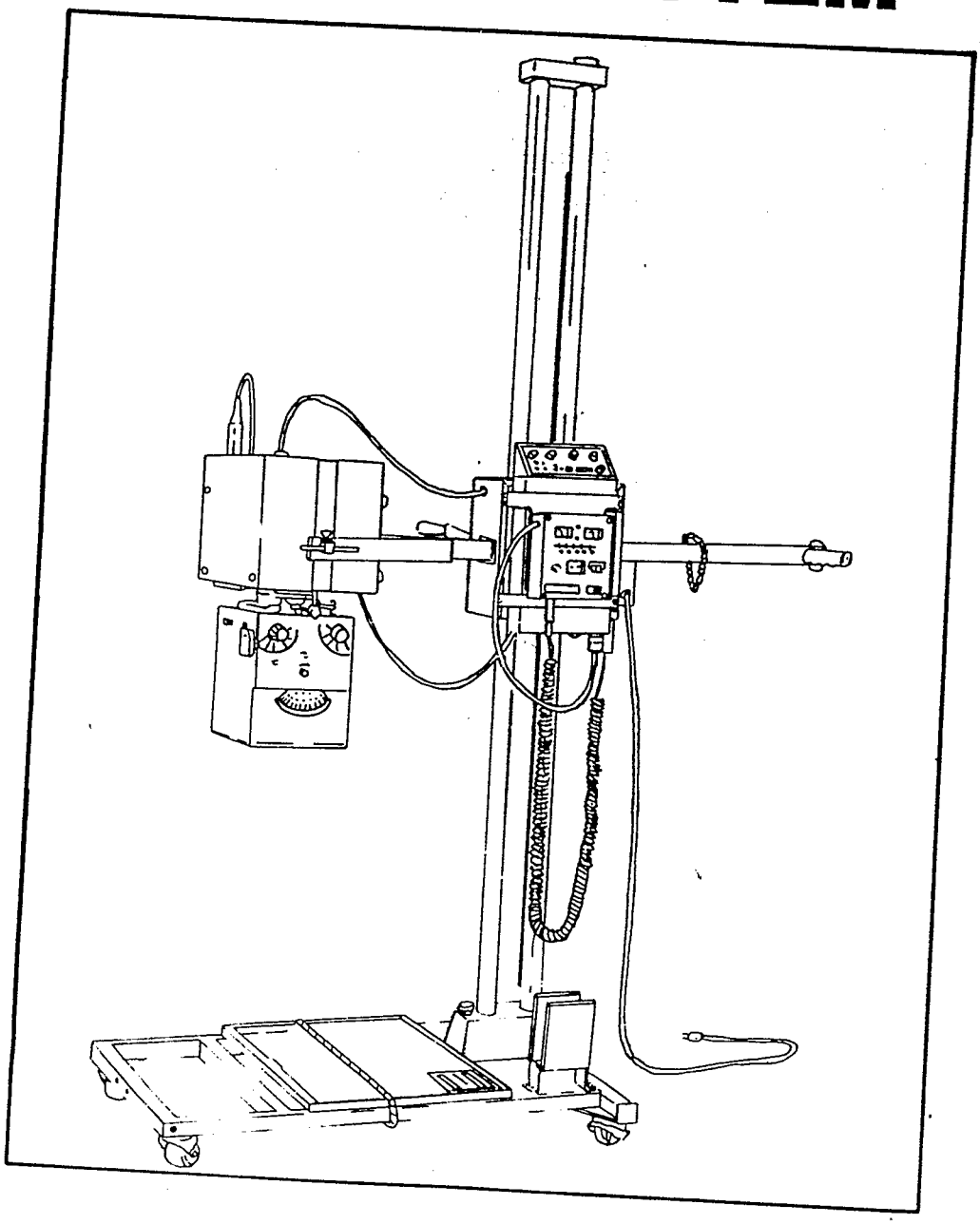
9160-MA

MAINTENANCE MANUAL
for
MODEL 9160M
X-RAY SYSTEM



porta ray inc.

19 JEFRYN BLVD. WEST, DEER PARK, NEW YORK 11729. 516-242-0022

RADIATION SAFETY PROCEDURES

WARNING

The X-Ray System incorporates a high degree of protection against x-radiation, other than the useful beam; however, operators should take adequate steps to prevent unwise or unknowing exposure to direct or secondary radiation. Persons authorized to use the equipment should be aware of the danger of excessive exposure to x-radiation and should be properly trained and instructed in its use. Various protective devices and materials are available. It is urged that such devices and materials be used.

INTRODUCTION TO THIS MANUAL

HOW TO USE THIS MANUAL

This manual is intended to provide an easily usable source of reference that will assist you in understanding the basics of the Model 9160M X-Ray System. The manual is arranged in six sections, each of which will support a general understanding of the X-Ray System. Complete table of contents, list of illustrations, and list of tables are included to help you locate any item of information in this manual.

PARAGRAPH, PAGE, FIGURE, AND TABLE NUMBERING SYSTEM

All paragraphs, pages, figures, and tables are assigned numbers keyed to the section and sequence in which they appear. For example, figure 2-1 is the first figure in Section 2, and figure 2-2 is the second figure in Section 2.

CONTENTS

The information presented in each section of this manual is as follows:

Section 1 - Introduction and Description. This section introduces the content of the manual; describes the X-Ray System, its purpose, function, and capabilities; and provides a table of leading particulars. Each major assembly of the X-Ray System is identified by an illustration.

Section 2 - Installation and Operation. This section will provide the instructions necessary to unpack and assemble the Model 9160M as well as complete instructions for its operation.

Section 3 - General Theory of Operation. This section provides a functional block description of the X-Ray System and also describes the function of each major assembly.

Section 4 - Maintenance. This section provides scheduled preventive maintenance (inspection, cleaning, and lubrication) instructions for the X-Ray System. This section also provides a list of performance standards, a troubleshooting chart, alignment and adjustment procedures, and replacement and disassembly procedures.

Section 5 - Parts List. This section includes a listing of parts, as well as supporting illustrations.

Section 6 - Diagrams. This section contains the X-Ray System schematic and wiring diagrams.

The Model 9160M X-Ray System manufactured by Porta Ray, Inc., 19 Jefryn Blvd. West, Deer Park, NY 11729, USA provides high quality x-ray capability in a portable format. It is intended for general medical applications where a compact, rugged, and highly mobile x-ray generator is required. The generator complies with the requirements of the United States Department of Health and Human Services for mobile and special purpose radiographic equipment.

CAUTION

X-ray equipment must always be used with great care. While the x-ray beam cannot be seen or felt, excessive exposure can cause great harm. The operator should take every precaution to restrict the area of exposure, dosage, and the frequency of exposure to the minimum required. The use of high-speed films and rare earth intensifying screens can greatly reduce the dosage required for a particular radiograph. Accordingly, the instructions contained herein should be read thoroughly and understood before attempting to place the equipment into operation.

It is assumed that all persons authorized to use the equipment are cognizant of the danger of excessive exposure to x-radiation and are fully acquainted with the recommendations of the National Committee on Radiation Protection as published in the National Bureau of Standards Handbooks of the American Standards Association, and of the International Commission on Radiation Protection. This equipment is sold with the understanding that Porta Ray, Inc., their agents, and representatives have no responsibility for injury or damage which may result from exposure to x-radiation.

LIMITED WARRANTY

Porta Ray, Inc. warrants its products to be free of manufacturing defects which will impair their normal operation when used within their specified ratings. Claims under this warranty must be made within one year after shipment from factory. Such warranty shall not apply to defects resulting from accidents, alterations, abuse, or misuse. X-ray tube warranty is limited to that provided by the manufacturer. Liability under this warranty is limited to repair or replacement of defective components at the factory. Shipping costs are not included. This warranty is in lieu of any other warranty expressed or implied.

FOR YOUR INFORMATION

The following keys are included throughout this manual to bring your attention to certain procedures and precautions. Each of these keys is intended for the following purposes:

NOTE: To highlight an instruction or procedure that requires special attention.

CAUTION: To bring your attention to an instruction or procedure which, if improperly performed, could damage the equipment.

WARNING: To bring your attention to an instruction or procedure which, if improperly performed, could cause bodily injury to the operator and/or patient.

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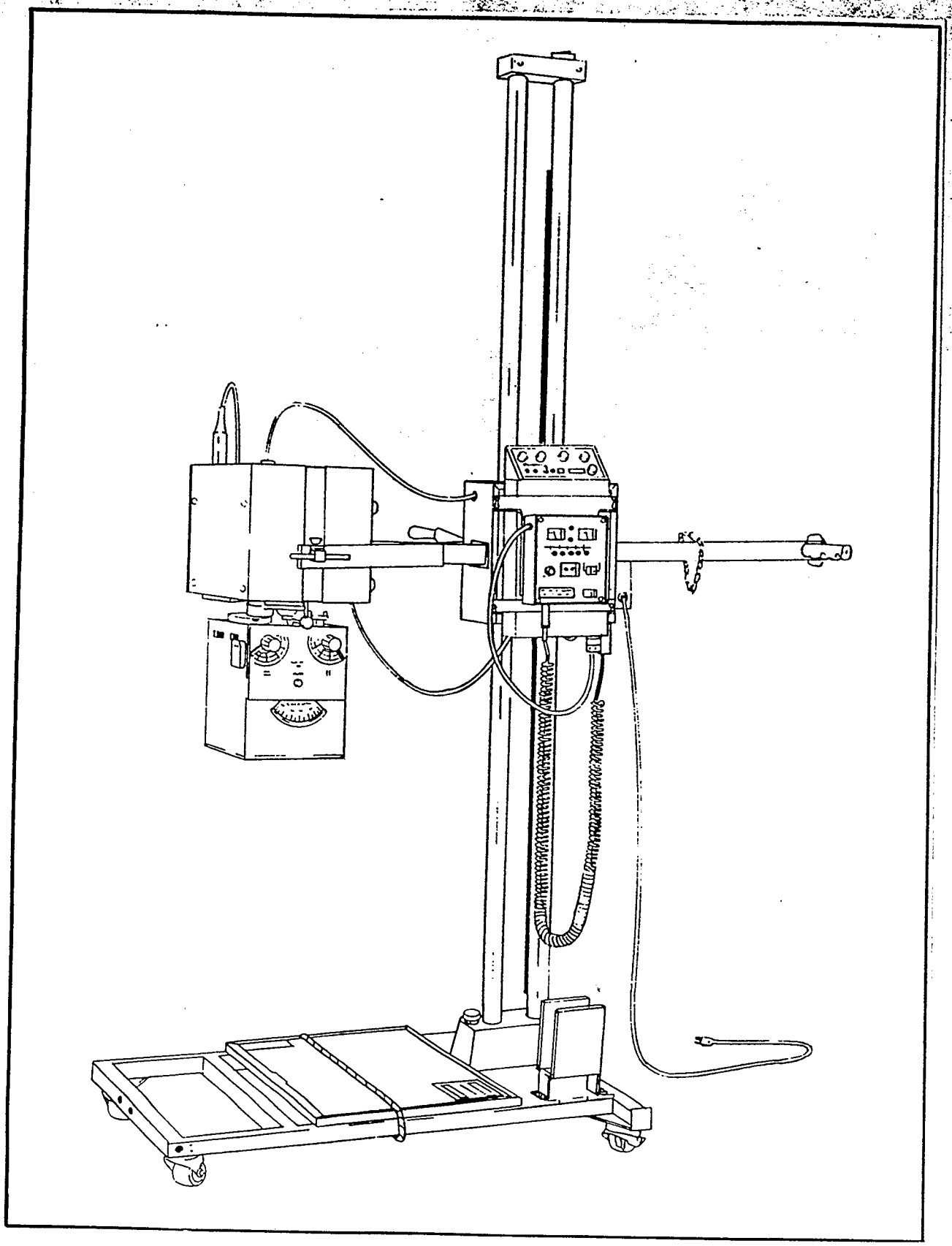


Figure 1-1. Model 9160M X-Ray System

SECTION 1
INTRODUCTION AND DESCRIPTION

1-1. INTRODUCTION

This manual provides service instructions for the Model 9160M X-Ray System, hereinafter referred to as the X-Ray System (see figure 1-1). The X-Ray System is manufactured by Porta Ray Inc., Deer Park, NY 11729.

This manual consists of six sections as follows:

Section 1. Introduction and Description
Section 2. Installation and Operation
Section 3. General Theory of Operation
Section 4. Maintenance
Section 5. Parts List
Section 6. Diagrams

1-2. PURPOSE AND FUNCTION

The X-Ray System is a lightweight, portable, diagnostic x-ray system, intended for use in small medical units, field hospitals, and for general-purpose radiographic examinations. The X-Ray System can establish the nature and extent of injury to personnel who may require evacuation to higher-level facilities or on-site treatment prior to evacuation.

Table 1-1 lists the leading particulars of the X-Ray System. Table 1-2 lists the leading particulars of the collimater which is described in detail in a separate supplementary manual. Table 1-3 lists the leading particulars of the Model 9160 Automatic Exposure Control (AEC) which is described in this manual. Table 1-4 is a list of items supplied, and Table 1-5 is a list of items required for calibration and test but not supplied.

1-3. CAPABILITIES AND LIMITATIONS

The X-Ray System meets the standards established by the Radiation Control for Health and Safety Act of 1968. The X-Ray System is capable of performing all field radiographic procedures. The X-Ray System has the capability of determining fractures and locating foreign bodies and secondary effects of trauma to the head, extremities, and abdomen. It can provide both bedside and litter diagnostic quality radiography under field conditions.

CAUTION

The X-Ray System is not designed to withstand an air drop.

The X-Ray System includes microprocessor-based automatic exposure control for use in the 20 to 30 mA and 60 to 100 kVp ranges and has the capability of selecting various film/screen combinations. The X-Ray System permits the use of commercially-available film and cassettes, as well as Polaroid film and the military Polaroid film processor.

Table 1-1. System Leading Particulars

PERFORMANCE SPECIFICATIONS	
kVp	Switch selectable; 60, 70, 80, 90, and 100 kVp nominal. Integral meter indicates actual kVp plus/minus 10%. kVp measurements performed with Keithley kVp Divider Model No. 35080.
mA	Automatically selected; 30 mA (60 kVp), 25 mA (70 and 80 kVp); and 20 mA (90 and 100 kVp) plus/minus 10% at 120 VAC line voltage. In addition, the mA may decrease by up to 30% at low line voltage (114 V) and maximum line regulation (5%). At high line voltage (124 V) the mA may increase by up to 30%. These variations keep the kVp relatively constant and, when high or low line voltage is indicated, the exposure time should be decreased or increased proportionately to maintain the mAs constant. Example: for a 0.1-second exposure at 120 V line, use a 16-impulse exposure at low line or an 8-impulse exposure at high line. Integral meter indicates value during exposure as a safety (not for calibration purposes). mA measurements performed with Model No. 245 Digital Multimeter by Data Precision Corp., Audubon Road, Wakefield, MA 01880.
Exposure Time	Selected by means of a two-digit thumbwheel switch in two ranges: SECONDS range, 0.1 to 2.9 seconds in 0.1-second steps, plus/minus 1%; IMPULSES range, 1 impulse to 29 impulses (1 impulse equals 1/120 second for 60 Hz or 1/100 second for 50 Hz) in 1-impulse steps, plus/minus 1%.
POWER	
Line Voltage Range	105 to 130 VAC, 200 to 250 VAC, 50/60 Hz when used with line power controller that adjusts voltage to within 115 to 125 VAC, 50 to 60 Hz operation controlled by panel switch.
Line Voltage Regulation	±5%
Technique Factor for Maximum Line Current	80 kVp - 25 mA
Maximum Line Current	30 amps - 120 VAC Line 20 amps - 220 VAC Line
BEAM ANGLE	15°
FOCAL SPOT SIZE	1 mm nominal

Table 1-1. System Leading Particulars - Continued

TARGET MATERIAL	Tungsten
POWER SUPPLY TYPE	Full wave
MINIMUM PERMANENT FILTRATION	2.5 mm of aluminum equivalent minimum at 100 kVp
LEAKAGE TECHNIQUE FACTORS	Testing is performed at 100 kVp and 0.9 mA continuous operation (3240 mAs/hour)

ASSEMBLED DIMENSIONS AND WEIGHTS

	Length (inches)	Width (inches)	Depth (inches)	Weight (pounds)
X-Ray Stand Assembly (Transport mode)	49	25	13	95
Control Module	8-1/2	10	2-5/8	3
X-Ray Generator	19	15-1/2	8-3/4	56
Automatic Exposure Control	17	10	3	8

ENVIRONMENTAL REQUIREMENTS

Storage Temperature	
Hot Limit	49°C (120°F)
Cold Limit	-18°C (0°F)
Operating Temperature	
Hot Limit	49°C (120°F)
Cold Limit	0°C (32°F)
Operating Humidity	5 to 95%

Table 1-1. System Leading Particulars - Continued

COOLING CURVES AND DUTY CYCLE

An automatic inhibit circuit provides a delay between exposures proportional to the exposure time. This delay is sufficient to allow proper tube cooling.

S-96P X-RAY TUBE TECHNICAL SPECIFICATIONS

Envelope	Hard glass throughout
Inherent Filtration	Approximately 1 mm aluminum equivalent
Target Angle	15° tilted anode type
Coverage	25°
Operation	Oil-immersed, center-grounded, full-wave rectified
Ratings:	
Maximum useful voltage	100 kVp
Maximum inverse voltage	110 kVp
Filament Characteristics:	
Voltage range	3.5 to 6.0 V
Current range	3.8 to 5.0 amps
Anode Heat Storage Capacity	15,000 H.U. (kVp x mA x sec)

Table 1-2. Collimater Leading Particulars

MAXIMUM kVp	125 kVp
OUTER DIMENSIONS	182 mm x 197 mm x 222 mm
NET WEIGHT	Approximately 6.2 kg
SHUTTER DRIVE	Two manual control knobs
PROJECTION LAMP	Philips Type 7158 Halogen Lamp, 24 V/150 W (rated)
POWER SUPPLY TO LAMP	19 VAC (under load) minimum, measured at lamp socket
LAMP TIMER	Pushbutton type, 30-second electronic timer
MINIMUM LINE CURRENT	6.0 amps at 19 VAC (under load)
MAXIMUM FIELD SIZE	35 cm x 35 cm at SID 65 cm
MINIMUM FIELD SIZE	Less than 5 cm x 5 cm at SID 100 cm
MINIMUM ALUMINUM EQUIVALENT	1.8 mm Al at 50 kVp
TUBE FOCAL DISTANCE	60 mm, at standard tube focal distance, from tube focus to bottom surface of adapter flange; adjustable between 60 mm and 52 mm by use of spacers supplied with each collimator
CONTRAST RATIO ON LIGHT FIELD EDGES	3.5:1 or more, to permit easy identification of light field and its size
MAXIMUM PERMISSIBLE LEAKAGE RADIATION	Within 50 mR/h at SID 100 cm
INSULATION RESISTANCE (between source circuit and a grounding metal)	2 megohms or more
ELECTRICAL RESISTANCE (between ground terminal or ground metal and outer case)	No more than 0.1 ohm

Table 1-3. Automatic Exposure Control Leading Particulars

kVp RANGE	50 - 150 kVp
CALIBRATION	Every 10 kVp with linear interpolation between calibration points.
FILM/SCREEN COMBINATIONS	Five different sets of kVp calibration points are included.
CALIBRATION METHOD	Calibration points digitally set by means of external terminal
mA RANGE	Up to 50 mA
MINIMUM EXPOSURE TIME	2.0 milliseconds
REPRODUCIBILITY	Better than 0.04 coefficient of variation.
DIGITAL DISPLAY	Four digit display of exposure time in milliseconds and mAs in 0.1 mAs increments.

Table 1-4. List of Items Supplied

Item	Qty	Model No./Part No.
X-Ray Stand Assembly	1	400TBS/500180
Control Module with Exposure Switch	1	1160/500151
Line Cord Assembly	1	/500139
Line Power Controller to X-Ray Generator Cable	1	/500255
AEC to X-Ray Generator Cable	1	/500251
Line Cord Adapter	1	/390160
X-Ray Generator Assembly	1	9160/500154
Automatic Exposure Control with X-Ray Sensing Detector	1	2000/500256
Line Power Controller	1	/500258

Table 1-5. List of Items Required but Not Supplied

Item	Qty	Model No./Part No.
Keithley kVp Divider	1	35080
Data Precision Digital Multimeter	1	245
Data Precision Counter	1	5740
Termiflex Hand-Held Terminal	1	HT/20
mA Test Plug (Standard stereo phone plug)	1	Commercially available

The X-Ray System can be operated in either manual or automatic mode. Manual mode permits the operator to select the kVp, mA, and exposure time with the aid of the appropriate technique chart. In automatic mode, the kVp/mA is set by the operator, while exposure time is controlled by the AEC using an x-ray sensing detector connected to the film cassette.

In an emergency, the X-Ray System can be shut down immediately by releasing the Exposure Switch, by switching the POWER ON switch on the line power controller to the off position, or by pulling the line cord plug out of the power receptacle.

NOTE

Complete operating, assembly, and setup instructions are provided in the Model 9160M X-Ray System Operator's Manual.

1-4. DESCRIPTION

A physical description and illustration of each of the system's major units is provided in the following paragraphs.

1-5. X-Ray Stand Assembly

The x-ray stand assembly (see figure 1-2) is used to house the major units of the X-Ray System, as well as to provide the wheels and carriage required to move the system to its point of use.

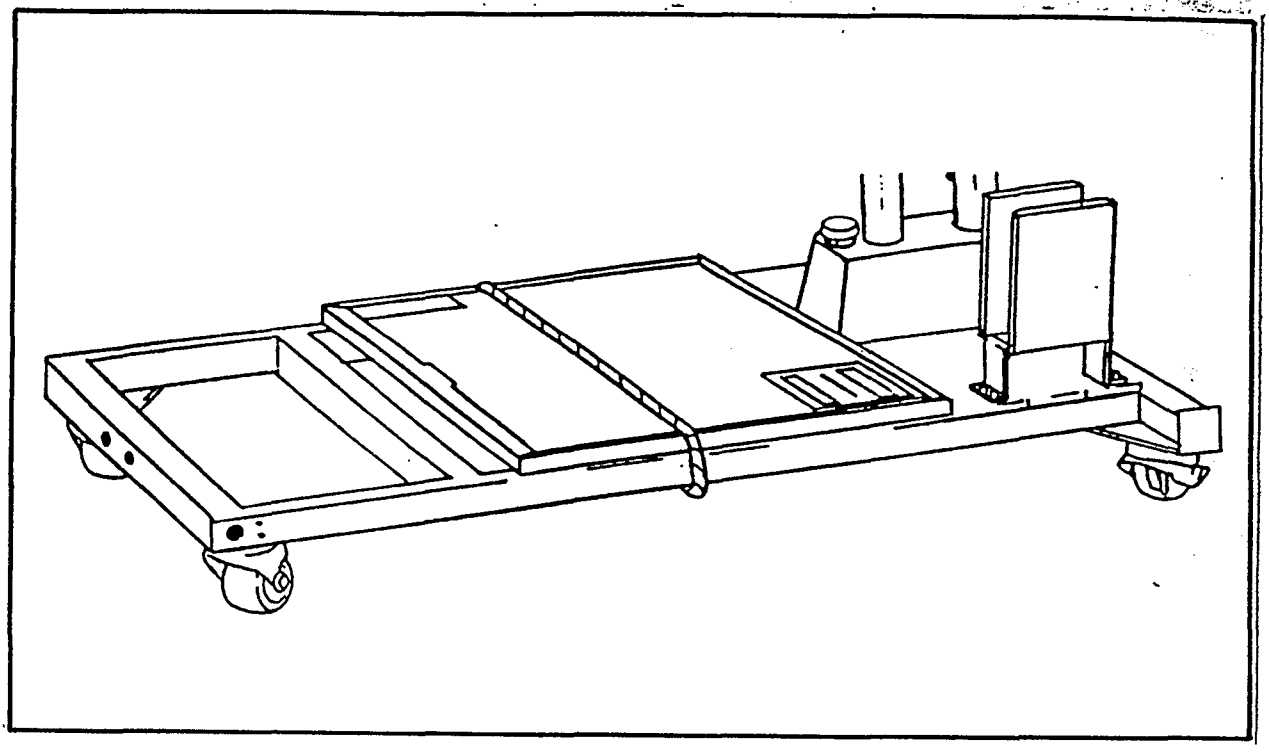


Figure 1-2. X-Ray Stand Assembly

The x-ray stand assembly is made up of the following major subassemblies:

- Base Assembly (P/N 500176)
- Gear Box Assembly (P/N 500023)
- Vertical Tube Assembly (P/N 500026)
- Cross Bar Assembly (P/N 500028)
- Yoke Assembly (P/N 500042)
- Line Power Controller (P/N 500258).

The assembly is shipped in its collapsed configuration, which is the configuration to be used whenever the system is transferred to another site. The stand assembly and the remaining X-Ray System units are designed for rapid assembly or disassembly prior to or after transport.

1-6. Control Module

The control module with the attached Exposure Switch (see figure 1-3) is mounted on the x-ray stand assembly. The module contains its own regulated power supplies and a digital timer. The solid-state digital timer provides precise exposure times without calibration adjustments. The control module is independent of the x-ray generator, to which it is connected. The control module houses all of the X-Ray System operating controls, except for the Exposure

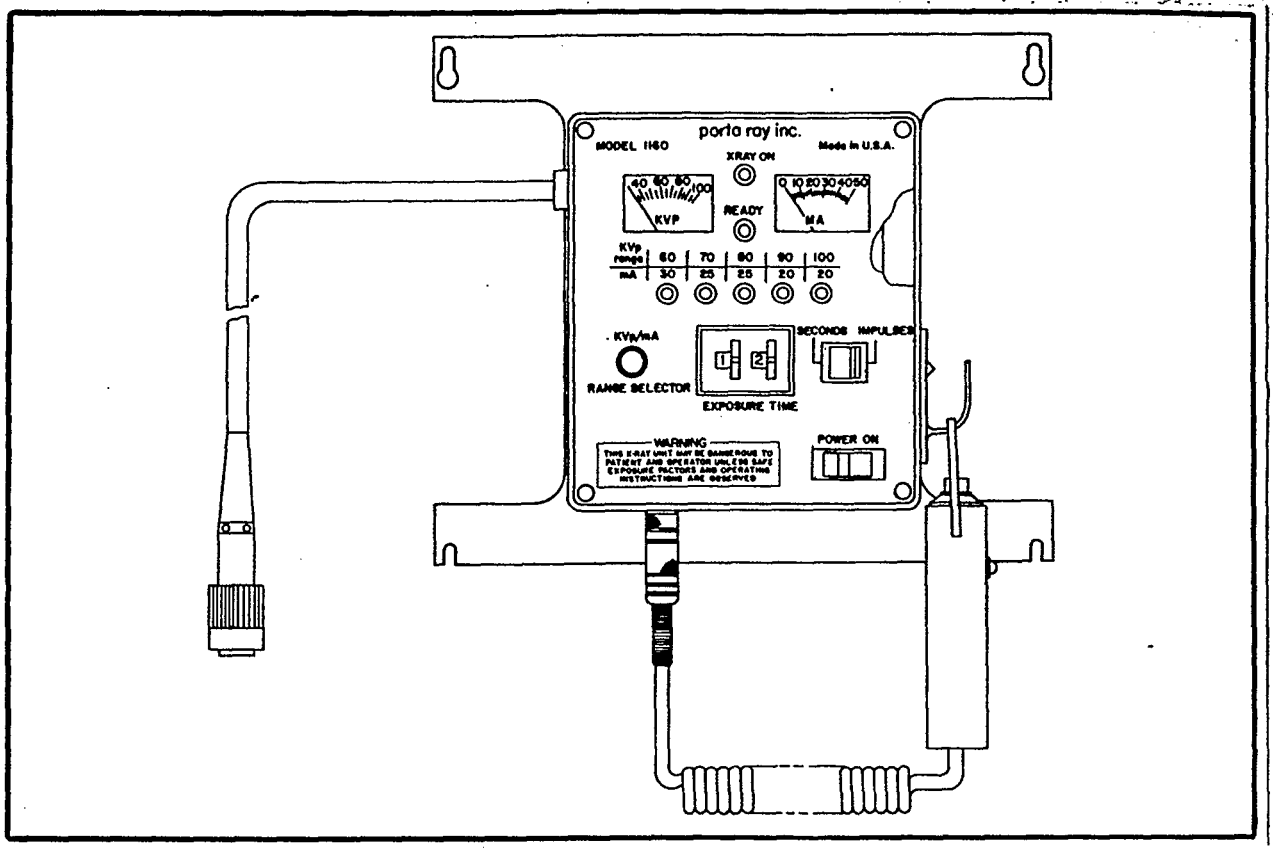


Figure 1-3. Control Module

Switch (hand-held control assembly) which is attached to it with a cable, and the automatic exposure control which has its own operating panel. Major components of the control module are:

- Case Assembly (P/N 500138)
- Timer Panel Assembly (P/N 500150)
- Exposure Switch (hand-held control assembly) (P/N 500163)
- PC Board Assembly (P/N 500140)
- Harness Assembly (P/N 500164)

1-7. X-Ray Generator Assembly

The x-ray generator assembly (see figure 1-4) houses the chassis assembly which includes: the filament supply that provides filament power to the x-ray tube, a means to select taps on the high-voltage transformer to obtain the correct kVp, and 24 VAC for the collimator lamp. The chassis assembly also houses the AC-to-DC mA converter PC board assembly.

The x-ray generator assembly contains the tube head assembly which is a sealed, oil-filled unit that includes the S-63P x-ray tube, the high voltage and filament transformers, and a high voltage bridge recifier.

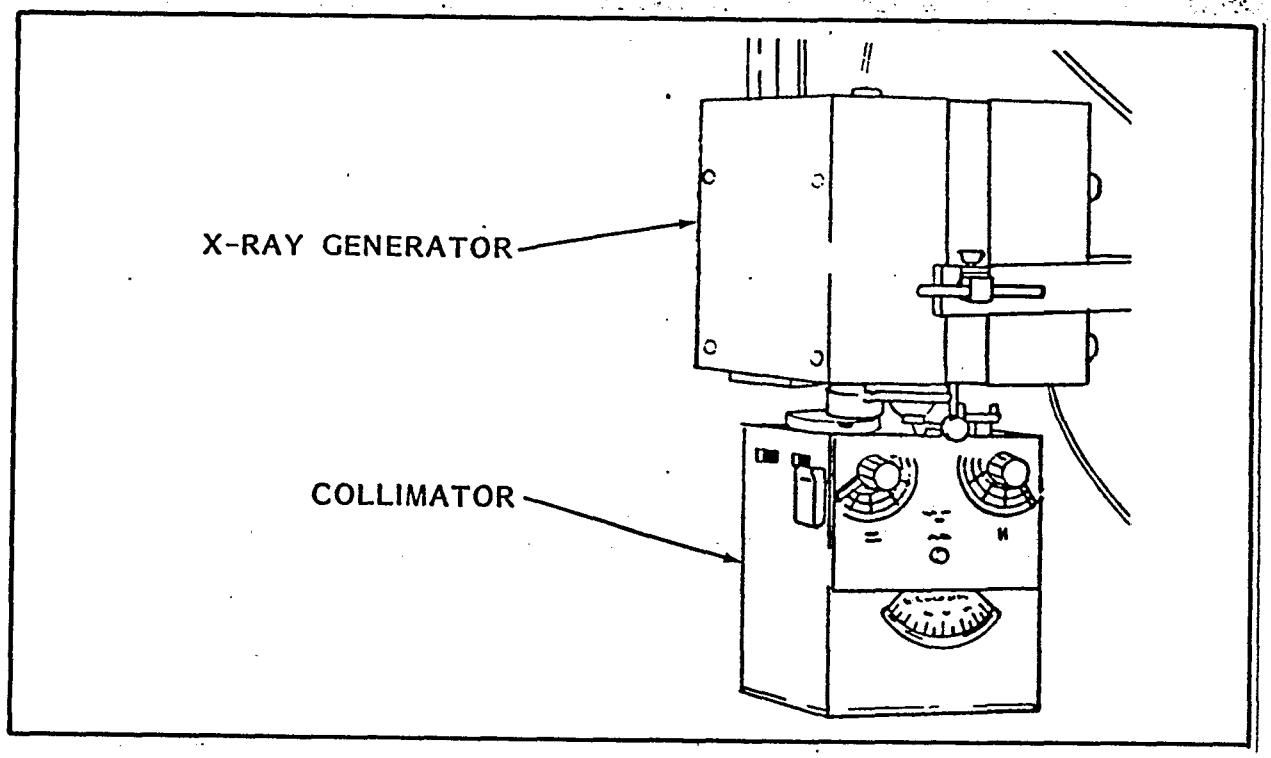


Figure 1-4. X-Ray Generator Assembly

The x-ray generator assembly also includes the collimator, which is described in more detail in its own manual (provided as an appendix to this manual) and the line cord assembly.

During assembly of the X-Ray System, the x-ray generator assembly is set in the yoke on the x-ray stand assembly.

1-8. Automatic Exposure Control

The AEC (see figure 1-5) incorporates microprocessor electronics and a solid-state detector to provide a lightweight, compact, and rugged unit that reduces retakes and provides consistent film density independent of the technician performing the examination. In addition, the AEC provides post-exposure mAs and exposure-time data. The AEC is used with the x-ray sensing detector described in paragraph 1-9.

The microprocessor also performs self-diagnostic tests. In many automatic exposure controls, if the detector is left out of the x-ray beam or is defective, the control runs until the backup timer terminates the exposure, thus subjecting the patient to a large unnecessary dose of radiation. The microprocessor in the AEC senses this situation and terminates the exposure within 20 milliseconds. In addition, a fault light illuminates and a fault number-code is displayed which indicates the nature of the problem to the operator.

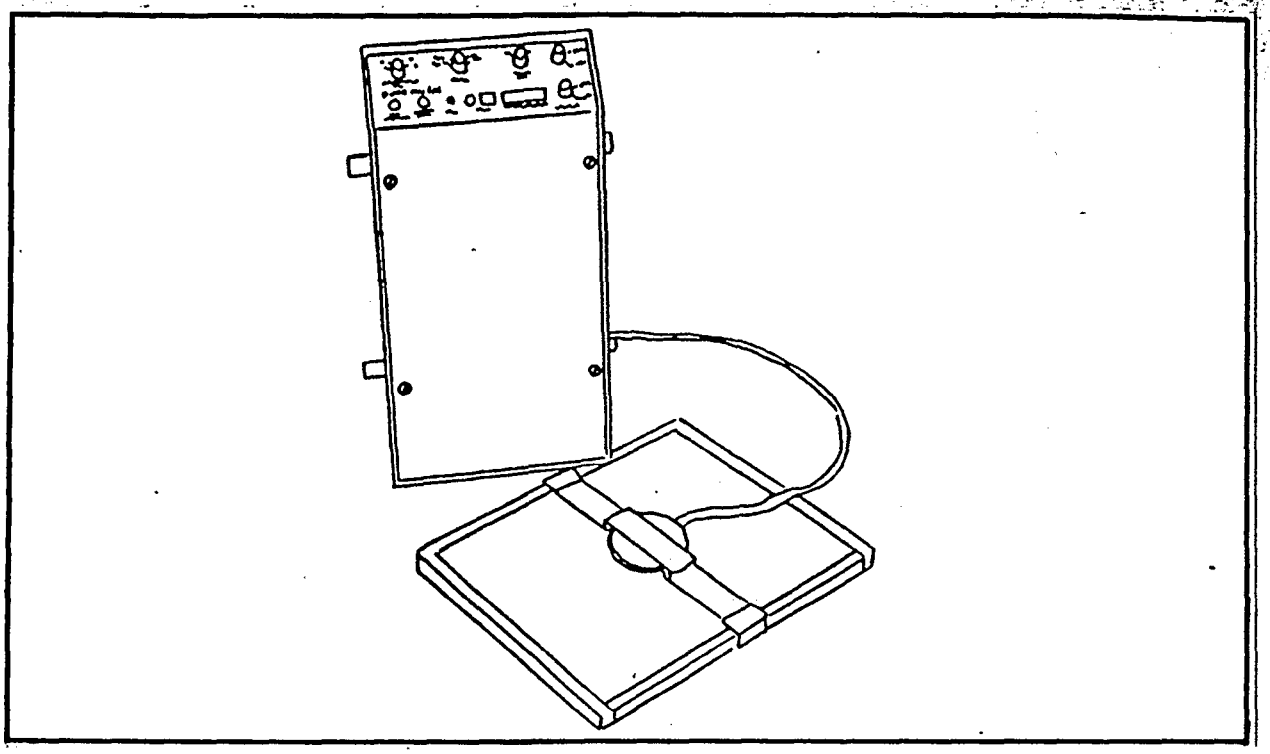


Figure 1-5. Model 9160 Automatic Exposure Control

1-9. X-Ray Sensing Detector

The x-ray sensing detector (see figure 1-6) is a sealed nonrepairable unit containing nine photoelectric cells. It is used to detect radiation and thus contributes to control of exposure time when used with the AEC.

1-10. Line Power Controller

The line power controller (figure 1-7), located on the x-ray stand assembly, permits the operator to select a wide range of AC line voltages to be used. The controller includes an autotransformer with selectable taps, a line voltage meter, a line voltage relay, and a voltage selector control pc board.

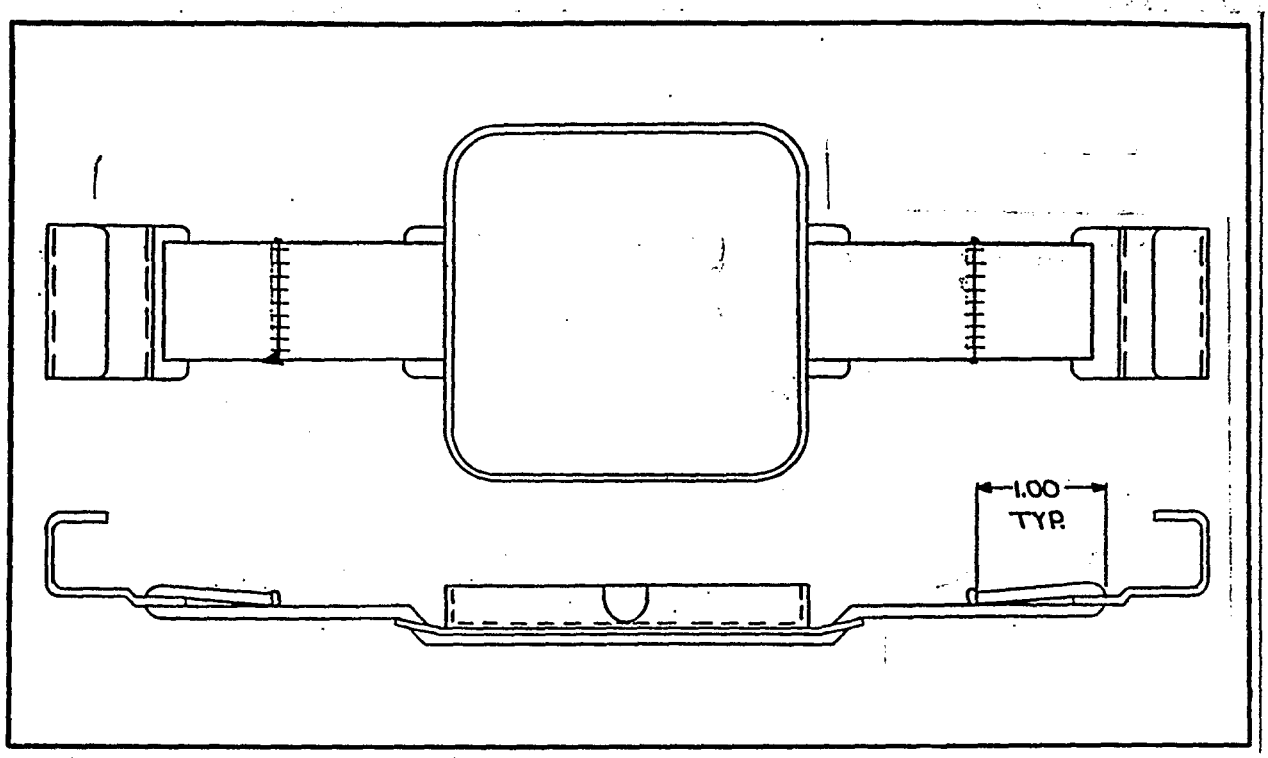


Figure 1-6. X-Ray Sensing Detector

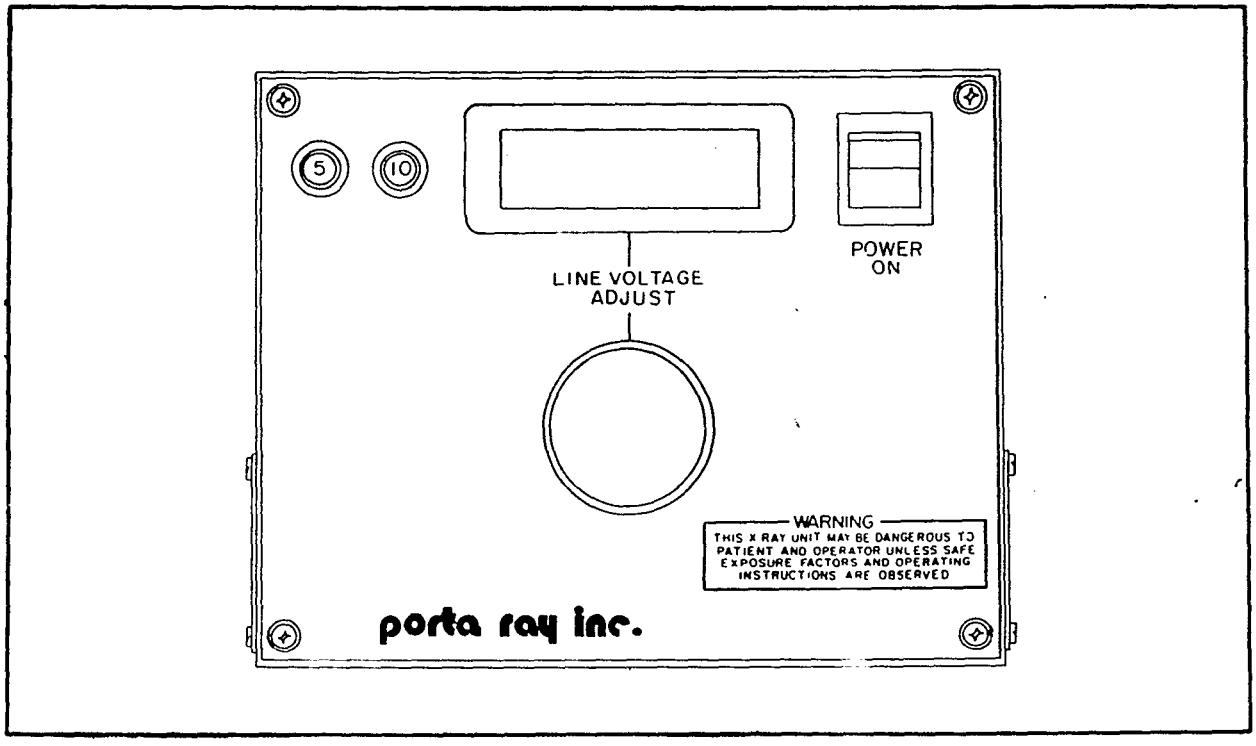


Figure 1-7. Line Power Controller

SECTION 2
INSTALLATION AND OPERATION

2-1. INTRODUCTION

This section contains instructions for installation, assembly, and electrical interconnection of the X-Ray System units, as well as reference to a preoperational checkout. The section also includes functions of controls, indicators, jacks, and connectors for the control module, the AEC and the line power controller. In addition, step-by-step operating procedures are provided for system operation in the standard (manual) and automatic exposure control mode.

Technique charts for use with the X-Ray System are enclosed at the end of this section.

2-2. INSTALLATION

The X-Ray System is a portable unit. Installation procedures required involve only the unpacking, inspection, assembly, and setup procedures described in the following paragraphs.

2-3. Unpacking and Inspection

Upon receipt of the X-Ray System, carefully examine the shipping container for any evidence of mishandling during shipment. Note the condition; if abnormal, carefully unpack the unit and examine it for damage.

If any damage is noted, it must be reported to the carrier promptly by filing a written report and personally calling it to their attention by phone, where possible.

NOTE

Do not ship the system back to the factory until the carrier has inspected the system and given written permission for reshipment back to the factory.

A separate manual is provided for adjustment and maintenance of the collimator. The collimator was installed and adjusted at the factory. The collimator manual should be kept for future reference.

2-4. Assembly and Setup

To prepare the X-Ray System for use, the system units must be assembled and set up as described in the following steps:

1. Mount the two 10-inch wheels to the base by inserting the shafts into the two holes provided at each side of the front of the base. An audible click will be heard when the shafts are properly installed.

2. Set the base on a level surface and lock the two locking swivel wheels before continuing with assembly.

3. Set the x-ray generator into the head container assembly on the base.

4. Using the handle, lower the cross bar and yoke assemblies to the x-ray generator.

5. Align the yoke latches with the openings on both sides of the x-ray generator and secure the x-ray generator to the yoke assembly by tightening the yoke latches.

6. Mount the AEC to the side of the gear box using the four shoulder screws.

7. Mount the control module to the AEC using the four shoulder screws on the AEC.

NOTE

If the AEC is not required the control module can be mounted directly to the gear box.

8. The X-Ray System is now in the ideal position for movement to the point of use.

NOTE

The X-Ray System is not ready for use until the electrical connections described in paragraph 2-5 are completed.

9. Unlock two locking swivel wheels and transport X-Ray System to point of use (figure 2-1).

10. Remove the two 10-inch wheels by pulling out on the mounting shafts.

11. Set the base on a level surface and lock the two locking swivel wheels.

12. Set the gear box assembly with control module on the lower tube assembly and set the lower tube assembly into the vertical tube holder assembly in the base.

13. Install the upper tube assembly in the lower tube assembly (figure 2-1).

14. Adjust height using the gear box assembly crank.

2-5. ELECTRICAL INTERCONNECTION OF UNITS

To complete electrical interconnection of the units in the X-Ray System, perform the following steps and refer to figure 2-2.

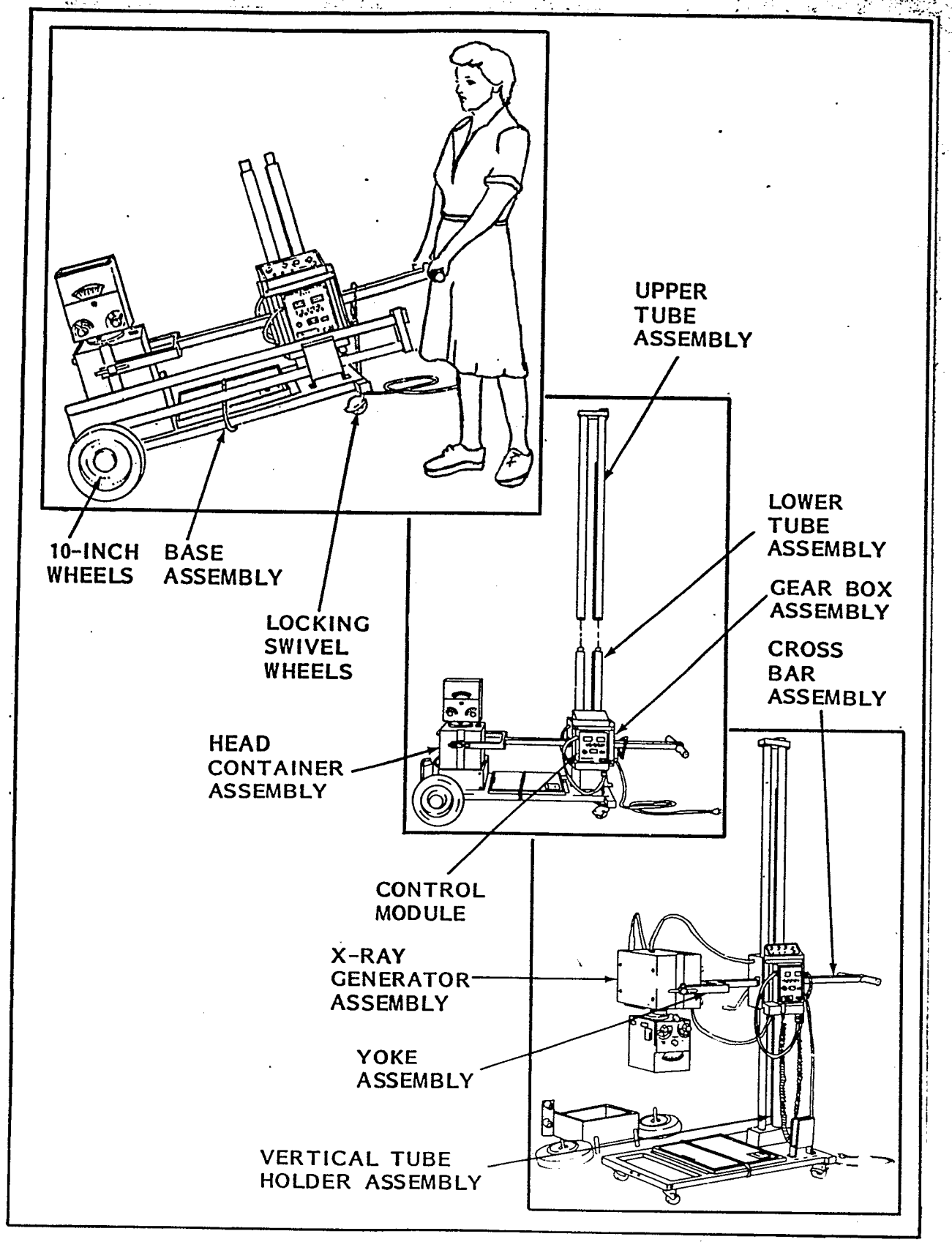


Figure 2-1. Setup of the X-Ray System

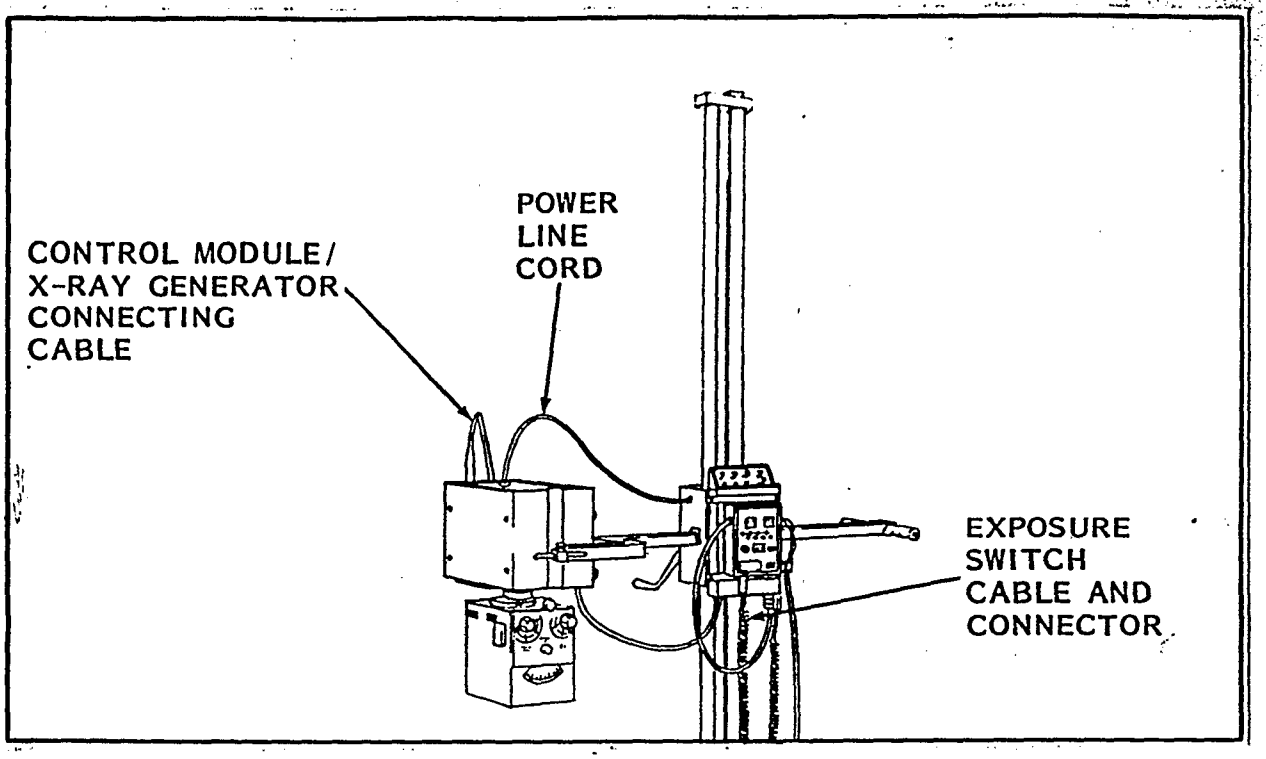


Figure 2-2. X-Ray System Interconnecting Cable Identification

NOTE

Reference to figures 2-3 and 2-5 may be made to assist in locating cable receptacles.

1. Connect the control module to the AEC by means of the connector located on the end of the cable attached to the control module.

NOTE

If the AEC is not required, the control module can be connected directly to the x-ray generator.

2. Connect the power line cord to the line power controller and the primary power source.

3. Connect the line power controller to the x-ray generator.

4. Connect the AEC to the x-ray generator.

2-6. PRE-OPERATIONAL CHECKOUT

To check the operation of the X-Ray System prior to actual use, perform the test described in table 4-2 of Section 4 of this manual.

2-7. OPERATION

2-8. Functions of Controls, Indicators, Jacks, and Connectors

The X-Ray System is designed for ease of operation with a minimum of adjustment. Table 2-1 provides a description of the controls and indicators on the control module operating panel. The control module controls and indicators may be identified by referring to figure 2-3. Functions of jacks and connectors are presented in table 2-2. Location of jacks and connectors is provided in figure 2-4. Table 2-3 describes the functions of operating controls and indicators on the AEC. The AEC controls and indicators may be located by referring to figure 2-5. Table 2-4 describes the AEC rear panel connectors which may be located by referring to figure 2-6. Table 2-5 describes the function of controls and indicators on the line power controller. The location of these controls and indicators is shown in figure 2-7.

2-9. OPERATING PROCEDURES

2-10. Standard System Operating Procedure

The standard X-Ray System operating procedure is described in the following steps.

1. Locate the X-Ray System at the desired distance from the film cassette. The technique charts in this section provide a guide for some common applications. The Model P180HS collimator contains a built-in tape measure to determine the distance accurately.

2. Operate the collimator lamp to locate the x-ray beam.

CAUTION

The projection lamp can become extremely hot.
The lamp should be used for only the time required.

3. Maneuver the x-ray generator until the light beam is centered on the film cassette. Adjust the shutters until the beam just covers the film cassette.

4. Select the kVp desired by means of the kVp/mA RANGE SELECTOR control on the control module.

5. Select the range of exposure time required by means of the SECONDS/IMPULSES (Time Range) Switch. Adjust the EXPOSURE TIME Control to the specific time required for the exposure.

6. Operate the POWER ON Switch to turn the primary power on. The POWER ON Indicator on the x-ray generator will illuminate. The kVp Meter will indicate the kVp selected. A higher or lower reading indicates a variation in the line voltage from the 120 V or 240 V nominal and the line power controller time setting can be modified to compensate.

Table 2-1. Control Module Controls and Indicators Functions

Figure 2-3 Index No.	Name	Function
1	X-RAY ON Indicator	A solid-state, light-emitting diode (LED) which illuminates when the Exposure Switch on the hand-held control assembly is pressed. This indicates the timed interval of x-ray output. In addition, an audio tone is generated at the same time. **NOTE** A second indicator is located on the handle of the Exposure Switch to provide another indication to the operator.
2	READY Indicator	A solid-state LED which illuminates when the system is ready for operation. The unit automatically prevents excessive operation by means of a time-delay circuit that is proportional (ca. 10:1) to the exposure time. Pressing the Exposure Switch on the hand-held control assembly will have no effect until the READY Indicator illuminates. This is a safety feature that prevents overheating of the x-ray tube that may be caused by excessively long periods of operation.
3	mA Meter	Indicates the actual mA during exposure (not for calibration purposes).
4	SECONDS/IMPULSES (Time Range) Switch	Operation of this switch permits selection of either the 0.1- to 2.9-second range (SECONDS) or the 1- to 29-impulse range (IMPULSES). **NOTE** 1 impulse equals 1/120 second for 60 Hz power and 1/100 second for 50 Hz power.
5	Exposure Switch	A momentary switch on the hand-held control assembly that controls operation of the x-ray beam. This is a "dead man" type switch and must be pressed continuously during the exposure. Releasing the switch will independently terminate the exposure and reset the timer. An X-RAY ON indicator is included on the handle of this switch.

Table 2-1. Control Module Controls and Indicators Functions - Continued

Figure 2-3 Index No.	Name	Function
6	POWER ON Switch	A rocker-type switch for controlling primary power to the x-ray generator. Operating the switch turns the unit on. Power should not be turned on until the X-Ray System is ready to use and should be turned off after use.
7	EXPOSURE TIME Control	Adjustment of this two-digit thumbwheel switch provides either 0.1 to 2.9 seconds in 0.1-second steps, or 1 to 29 impulses in 1-impulse steps, depending on the position of the SECONDS/IMPULSES (Time Range) switch (4). The decimal point is not used in the impulse range.
8	kVp/mA RANGE SELECTOR Control	The desired kVp range may be selected with this control. One of five LED indicators (9) will illuminate to indicate the kVp range. The kVp selected can be verified by the reading of the kVp Meter (10).
9	kVp RANGE, mA Indicators	Five indicators, one of which will light to indicate the selected kVp range and mA.
10	kVp Meter	Indicates the kVp selected. Variations in input line voltage from 120 V nominal will cause a proportional variation in the indicated kVp.

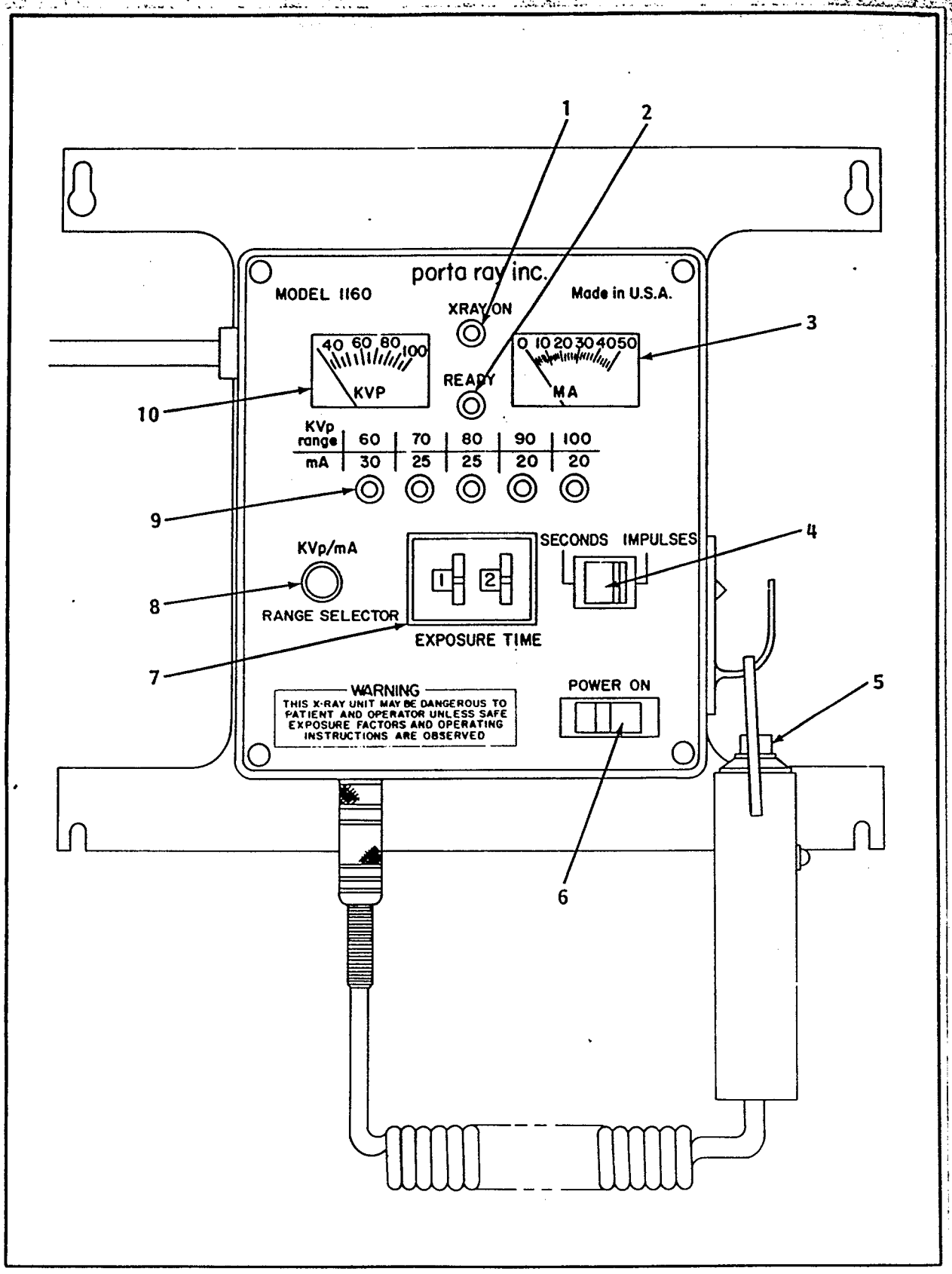


Figure 2-3. Location of Control Module Operating Controls and Indicators

Table 2-2. Jacks and Connectors Functions

Figure 2-4 Index No.	Name	Function
1	Exposure Switch Jack	A connector that allows removal of the Exposure Switch.
2	Collimator Rotation Lock	To unlock the collimator, turn the shaft counterclockwise to allow collimator to rotate.
3	Power Supply	Power supply for light beam collimator.
4	REMOTE Connector	For control module. **CAUTION** Do not attempt to operate the system without the control module, as permanent damage will result.
5	POWER ON Indicator	Illuminates when power is applied to the system .
6	RESET Circuit Breaker	A red shaft extends when excessive line current is drawn. Press to reset. Repeated failure indicates a repair is required.
7	AC INPUT Connector	Connection to line power controller. **CAUTION** Adjust line power controller to within the indicated limits. Excessive voltage can damage the x-ray generator.

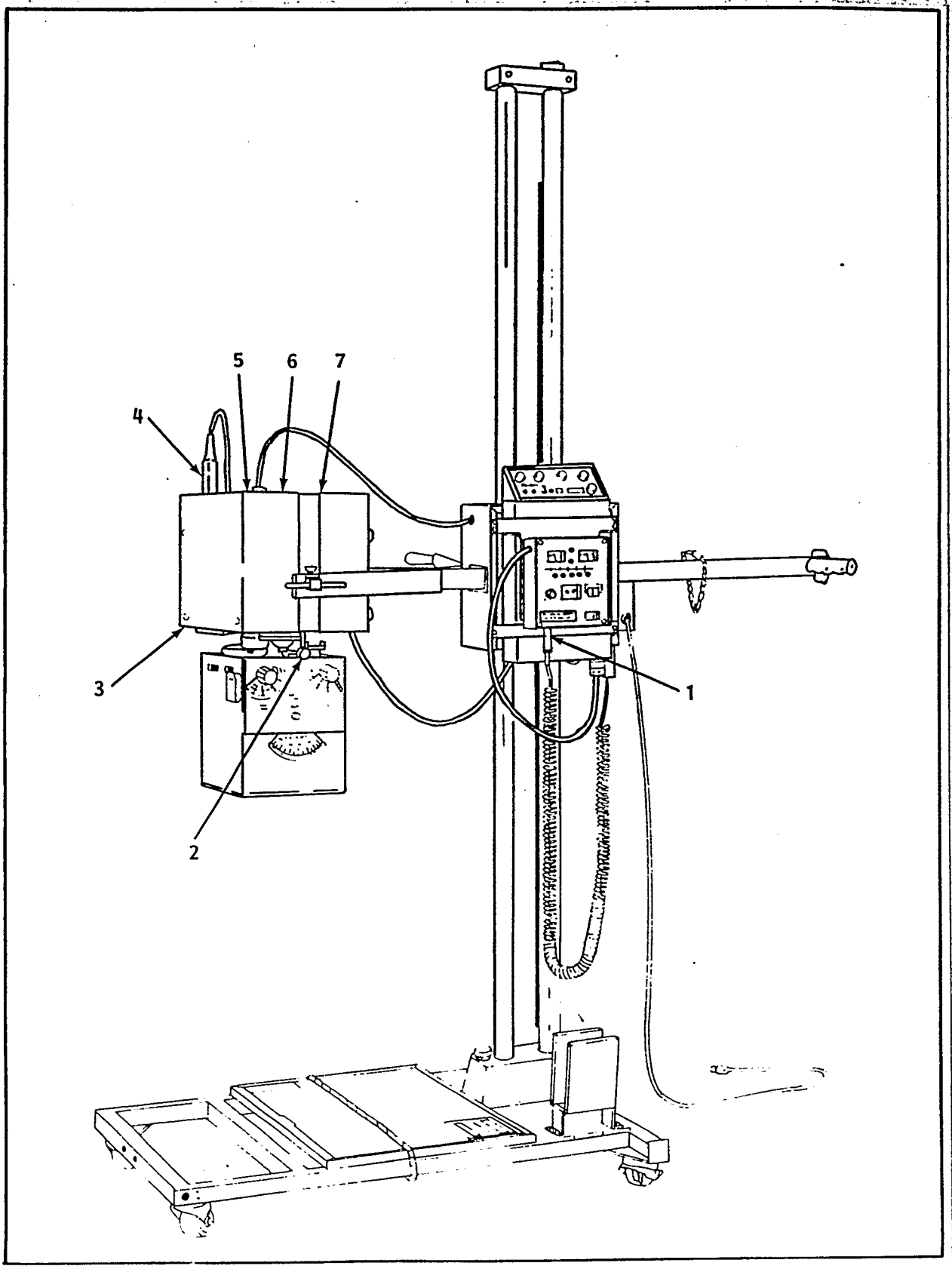


Figure 2-4. Locations of Jacks and Connectors

Table 2-3. Automatic Exposure Control, Functions of Controls and Indicators

Figure 2-5 Index No.	Name	Function
1	ON/OFF Switch	A two-position switch used to select either automatic or manual operation.
2	mAs/SEC Switch	A two-position switch which selects mAs or exposure time (in milliseconds) to be displayed in the Exposure Factor (3) display. **NOTE** Both readings are retained in memory. The switch may be moved back and forth without losing information.
3	Exposure Factor Digital Readout	A four-digit display which indicates either mAs or exposure time of the previous exposure, depending upon the position of the mAs/SEC switch (2).
4	FAULT Digital Readout	A one-digit display that indicates the nature of the problem when the FAULT Indicator (5) is lit
5	FAULT Indicator	Illuminates red to indicate a fault condition. Additional exposures are prevented until the RESET Switch (6) is pressed.
6	RESET Switch	A momentary switch which, when pressed, resets the system and clears any fault conditions.
7	GEN Indicator	Illuminates red to indicate that the exposure was terminated by the backup timer. Further exposures are prevented until the RESET Switch (6) is pressed.
8	AUTO (Exposure) Indicator	Illuminates green after a successful automatic exposure.
9	FILM SYSTEM Switch	A five-position switch used to select one of five different film/screen calibrations
10	DENSITY Switch	A five-position switch used to vary film density from -50% to +50%.
11	SIZE (Patient) Switch	A three-position switch used to adjust for small, medium, or large patient size.

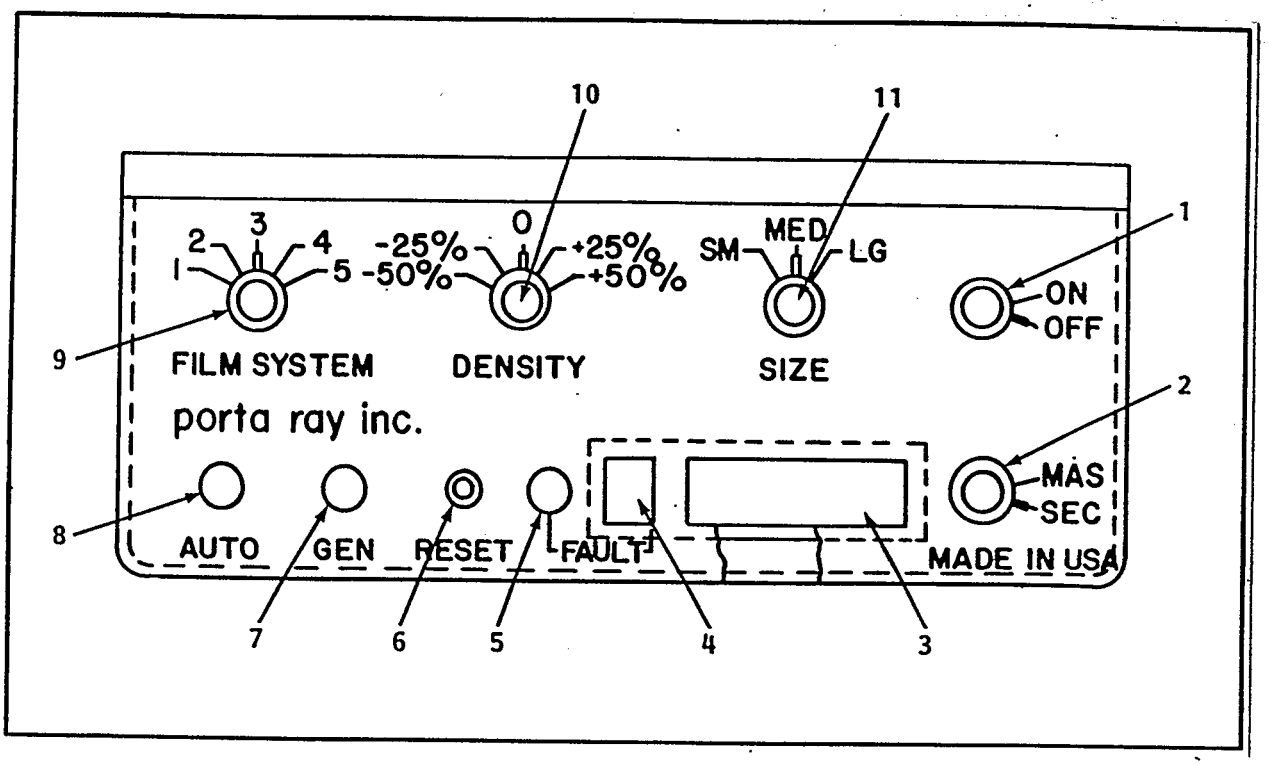


Figure 2-5. Automatic Exposure Control, Locations of Controls and Indicators

Table 2-4. Automatic Exposure Control, Functions of Rear Panel Connectors

Figure 2-6 Index No.	Name	Function
1	14-pin Male Connector	Connects AEC to x-ray generator.
2	15-pin D-Subminiature Connector	Connects AEC to Hand Held Calibration Terminal.
3	BNC Receptacle/ Connector	Connects AEC to x-ray detector.
4	14-pin Female Connector	Connects AEC to control module.

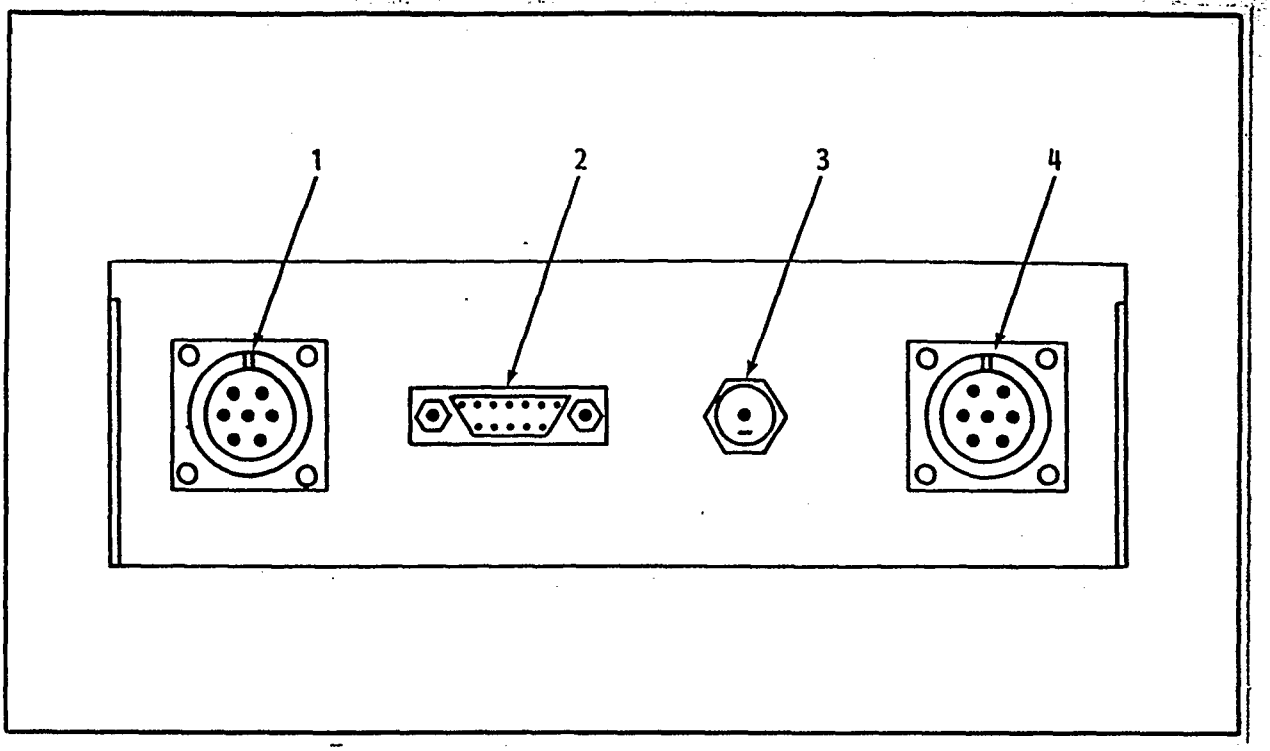


Figure 2-6. Automatic Exposure Control, Identification of Rear Panel Connectors

Table 2-5. Line Power Controller, Function of Controls, Indicators and Connectors

Figure 2-7 Index No.	Name	Function
1	Circuit Breaker CB1	Controls potential overloads on 220 VAC input line.
2	Circuit Breaker CB2	Controls potential overloads on 120 VAC input line.
3	LINE VOLTAGE ADJUST Meter M1	When pointer is within green band, the proper line voltage is available.
4	POWER ON Switch	In ON position, used to apply line voltage to the X-Ray System.
5	Connector J1	Connects 120 V power out to x-ray generator.
6	LINE VOLTAGE ADJUST Switch	Transformer tapped switch used to fine adjust line voltage. (Fine adjustment is achieved when meter M1 pointer is within meter green band.)
7	Connector J2	Input power connector.

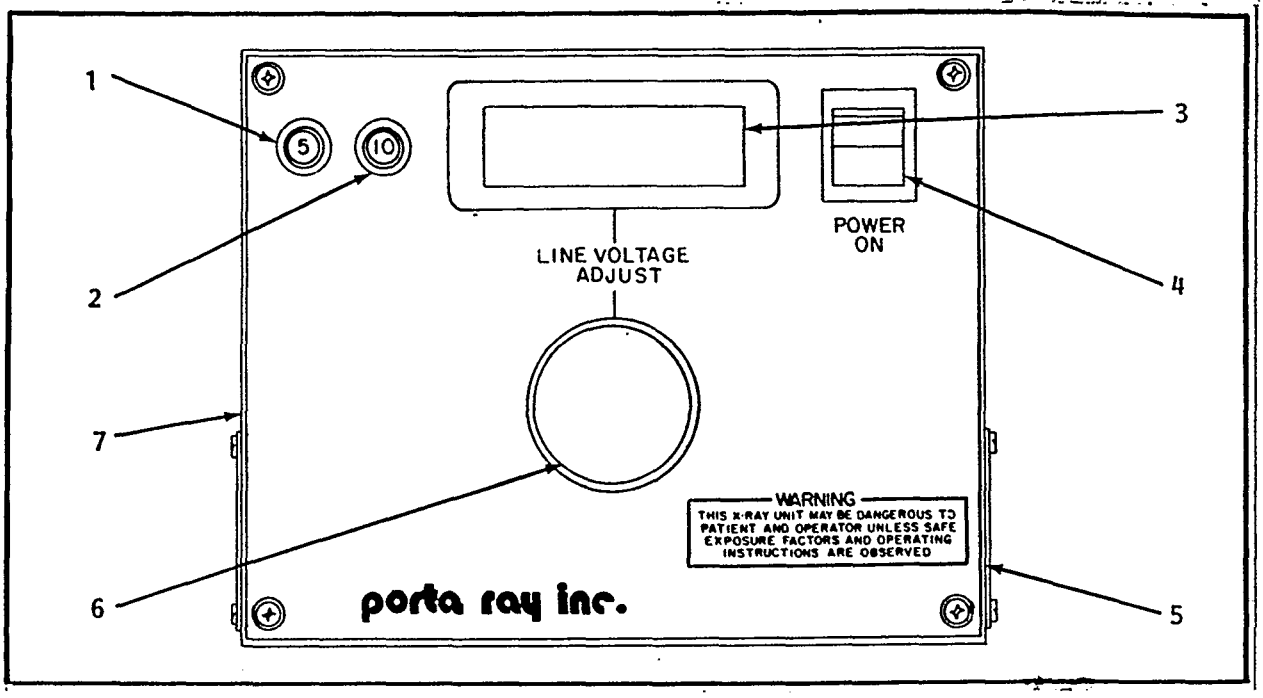


Figure 2-7. Line Power Controller, Location of Controls and Indicators

7. After the required warmup period, the READY Indicator will illuminate. It is not possible to operate the unit until this has occurred. If the unit has not been operated for a long period of time an additional 2-minute waiting period is required.

8. While holding the Exposure Switch, step at least 6 feet (2 meters) to the rear or side of the X-Ray System.

9. Press the Exposure Switch and maintain pressure to operate the x-ray generator. Removal of pressure from the Exposure Switch terminates the x-ray. During the exposure, the X-RAY ON Indicator on the control module and the indicator on the Exposure Switch handle illuminate, an audio alarm sounds, and the mA meter deflects, indicating the presence of x-ray beam current. At the end of the required time interval, the control module terminates the exposure, the operating indicators turn off, and pressure may be removed from the Exposure Switch. If the x-ray is terminated prior to completion of the selected time interval, the timer automatically resets.

10. Unless the x-ray generator is going to be used again immediately, press the POWER ON Switch to turn the unit off. Leaving the unit in the "on" condition provides opportunity for accidental operation and shortens the life of the x-ray tube.

11. If the unit is to be operated again, an automatic inhibit circuit allows the x-ray tube to cool in proportion to the on-time to prevent damage to the x-ray tube from overheating. At the end of this period, the READY indicator again illuminates and exposure may proceed.

2-11. Operating Procedure For Automatic Exposure Control

To operate the X-Ray System in either manual or automatic mode, perform the following procedures.

For manual operation:

Place the ON/OFF Switch in the OFF position and use the equipment normally as described in paragraph 2-10.

For automatic operation perform the following steps:

1. Attach the x-ray detector to the rear of the cassette and position the detector under the area of interest. Position cassette under patient.
2. Set kVp/mA RANGE SELECTOR on the control module to the desired value.
3. Set the exposure time control on the control module to a value 50% greater than anticipated.
4. Set the AEC ON/OFF Switch to ON.
5. Adjust the AEC FILM SYSTEM Switch to the type being used. If only one type is used, leave the switch in position 1.
6. If a lighter or darker than normal density is required, adjust the AEC DENSITY Switch. If not, leave at zero.
7. Adjust the patient SIZE Switch to correspond to the size of the patient (small, medium, large).
8. Step back and make the exposure in the normal manner.
9. At the end of the exposure when the AEC green AUTO (Exposure) indicator lights, record both the mAs and exposure time values, if required.

2-12. TECHNIQUE CHARTS

Technique charts specifically for use with the X-Ray System are included herein as figures 2-8, 2-9, and 2-10. The charts include kVp settings for high speed screens, par speed screens, and rare earth screens.

technique chart

HIGH SPEED SCREENS – 40 Inch Distance

EXAM.	kVp	SECONDS	VIEW.
Chest	100	.3 – .4	A.P.
	100	.7 – 1.0	Lateral
Foot	60	.2 – .3	A.P.
	60	.3 – .4	OBLIQUE
	60	.4	Lateral
Tibia Ankle	100	.3	A.P.
	100	.3	OBLIQUE
	100	.3	Lateral
Tibia	100	.3 – .4	A.P. & Lateral
Knee	100	.2 – .3	A.P. & Lateral
Femur	100	.6 – .8	A.P. & Lateral
Hip (Grid)	100	.3 – .5	A.P. & Frog
Lumbar Spine (Grid)	100	.4 – .6	A.P.
	100	.8 – 1.5	Lateral
Cervical Spine	100	.4 – .5	A.P.
	100	.4 – .5	Lateral
Hand	60	.2 – .3	P.A.
	60	3 – .4	OBLIQUE
	60	.4 – .5	Lateral
Elbow	60	.3 – .4	A.P.
	60	.3 – .4	Lateral
Humerus	100	.4 – .5	A.P. & Lateral
Shoulder	100	.3 – .4	A.P.
Skull (Grid)	100	.5 – .6	A.P.
	100	.3 – .4	Lateral
Mandible (Grid)	100	.5 – .6	P.A.
	100	.2 – .3	OBLIQUE
Nasal Bones (Grid)	100	1.0 – 1.5	Waters
	60	.5 – .7	Lateral
Ribs	100	.3 – .5	A.P.
	100	4 – .6	OBLIQUE
Chest	80	.4 – .5	A.P.
	80	.8 – 1.2	Lateral
Foot	80	1/60	A.P. – OBLIQUE
	80	.1 (1/10)	Lateral
Ankle	80	.4	A.P. – LAT–OBLIQUE
Tibia	80	.4 – .5	A.P. – LAT.
Knee	80	.3 – .4	A.P. – LAT.
Femur	80	.7 – .9	A.P. –LAT.
Hip (Grid)	80	.4 – .6	A.P. – Frog
Lumbar Spine (Grid)	80	.5 – .7	A.P.
	80	.9 – 1.6	Lateral
Cervical Spine	80	.5 – .6	A.P. – LAT.
Hand	80	.1 – .2	P.A. – OBLIQUE
	80	.3 – .4	Lateral
Elbow	80	.2 – .3	A.P. – LAT.
Humerus	80	.3 – .4	A.P. – LAT.
Shoulder	80	.2 – .3	A.P.
Skull (Grid)	80	.6 – .7	A.P.
	80	.4 – .5	LAT.
Ribs	80	4 – .6	A.P.
	80	.5 – .7	OBLIQUE

NOTE! This technique chart is to be used as a guide Your technician may make adjustments to fit your installation and needs.

Figure 2-8. X-Ray System Technique Chart for High Speed Screen

technique chart

PAR SPEED SCREENS, 40 Inches

EXAM	kVp	SECONDS	VIEW
Chest	100	.5 – .7	A.P.
	100	1.5 – 2.0	Lateral
Foot	60	.6 – .7	A.P.
	60	.7	OBLIQUE
	60	.8	Lateral
Ankle	100	.6	A.P.
	100	.7	OBLIQUE
	100	.6	Lateral
Lower Leg	100	.7 – .8	A.P. & Lateral
Knee	100	.5 – .6	A.P. & Lateral
Femur	100	1.5 – 1.8	A.P. & Lateral
Hip (Grid)	100	.4 – .7	A.P. & Frog
Lumbar Spine (Grid)	100	.6 – .8	A.P.
	100	1.5 – 2.0	Lateral
Cervical Spine	100	.8 – 1.0	A.P.
	100	1.0	Lateral
Hand	60	60 .4 – .6	P.A.
	60	.6 – .8	OBLIQUE
	60	.8 – 1.0	Lateral
Elbow	60	.6 – .8	A.P.
	60	.7	Lateral
Humerus	100	.8 – 1.0	A.P. & Lateral
Shoulder	100	.6 – .8	A.P.
Skull (Grid)	100	1.0 – 1.3	A.P.
	100	.7 – .8	Lateral
Mandible (Grid)	100	1.0 – 1.5	P.A.
Par Speed	60	.4 – .6	OBLIQUE
Nasal Bones (Grid)	100	2.0 – 2.5	Waters
Par Speed	60	1.0 – 1.5	Lateral
Ribs	100	.6 – 1.0	A.P.
	100	.8 – 1.2	OBLIQUE

NOTE: This technique chart is to be used as a guide. Your technician may make adjustments to fit your installation and needs.

Figure 2-9. X-Ray System Technique Chart for Par Speed Screen

technique chart

EXAM.	kVp	Seconds	mA	Dist.	Grid	Comments
Chest – P.A.	100	.3 to .4	15	40 in.	no	Average
Chest – Lat.	100	.8 to 1.5	15	40 in.	no	Patient
Chest – P.A.	100	.5 sec.	15	72 in.	no	"
Chest – Lat.	100	2 to 2.5	15	72 in.	no	"
Foot – A.P.	100	1/10	15	30 in.	no	"
Tibia – Ankle	100	2/10	15	30 in.	no	"
Knee	100	3/10	15	30 in.	no	"
Femur	100	2 sec.	15	30 in.	no	"
Hip, A.P. & Frog	100	3 sec.	15	30 in.	yes-6:1	"
Lumbar Spine	100	3.5 sec.	15	30 in	no	"
Cervical Spine A.P.	100	6/10	15	30 in.	no	"
Cervical SpineLat.	100	8/10	15	40 in.	no	Cross Table
Hand	100	1/10	15	40 in.	no	Average Patient
Elbow	100	2/10	15	36 in.	no	"
Humerous	100	1/2	15	36 in.	no	"
Shoulder	100	6/10	15	40 in.	no	"
Skull – A.P.	100	2 sec.	15	30 in.	yes-6:1	"
Skull – Lat.	100	1 sec.	15	30 in.	yes-6:1	"
Nasal Bones-Waters	100	2.5 sec.	15	30 in.	yes-6:1	"
Nasal Bones-Lat.	100	3/10	15	30 in.	no	"
Dorsal Spine-A.P.	100	1 sec.	15	30 in.	no	"
K.U.B.	100	3 sec.	15	40 in.	no	"

NOTE: This technique chart is to be used as a guide. Your technician may make adjustments to fit your installation & needs.

Figure 2-10. X-Ray System Technique Chart for Rare Earth Screens

SECTION 3
GENERAL THEORY OF OPERATION

3-1. INTRODUCTION

This section provides a functional block description of the complete X-Ray System, with each of the functional blocks described in its normal operating sequence. The functional block description is supported by a simplified system functional block diagram. The functional operation of each of the printed circuit (pc) boards used in the X-Ray System is also described in this section.

3-2. FUNCTIONAL BLOCK DESCRIPTION

This description traces the functional operation of the X-Ray System through each of the units that contribute to its operation. Reference is made to the X-Ray System simplified system functional block diagram, figure 3-1, to supplement the description. The X-Ray System operates in either manual or automatic mode. In manual mode, the operator may select kVp, mA, and exposure time with the aid of the technique charts included in Section 2 of this manual. During operation in automatic mode, kVp/mA exposure control is set by the operator. Exposure time is controlled by the x-ray sensing detector connected to the film cassette.

After the patient, the film cassette, and the x-ray detector are positioned as shown in figure 3-1, the sequence of operation in the X-Ray System can begin. The sequence is initiated when the POWER ON switch on the line power controller is set to on, a line voltage is selected by the line power controller line voltage selector, the control module is turned on, the kVp and exposure time are set on the control module, and the Exposure switch is pressed.

A timed signal is then generated by the timer pc board in the control module and forwarded to the signal function of display pc board A1 and photo timer (microprocessor) pc board A2, both in the AEC control unit. The kVp selected at the control module is also routed to the microprocessor and to the mA/kVp adjustments circuit.

The timed signal is then routed through a solid-state relay in the x-ray generator unit, to the high voltage transformer, which also receives the kVp select signal from the control module, via the mA/kVp adjustments circuit which also activates the x-ray tube filament and transformer.

The high voltage transformer activates the x-ray tube via the high voltage bridge rectifier, and the x-ray exposure begins. X-rays pass through the patient, expose the cassette, and are detected by the x-ray detector.

At this time, detected signals from the detector and mA signals from the high voltage transformer are routed back to the microprocessor. When the microprocessor determines that the proper exposure has been made, it generates a stop signal to the control module timer pc board, which terminates the exposure.

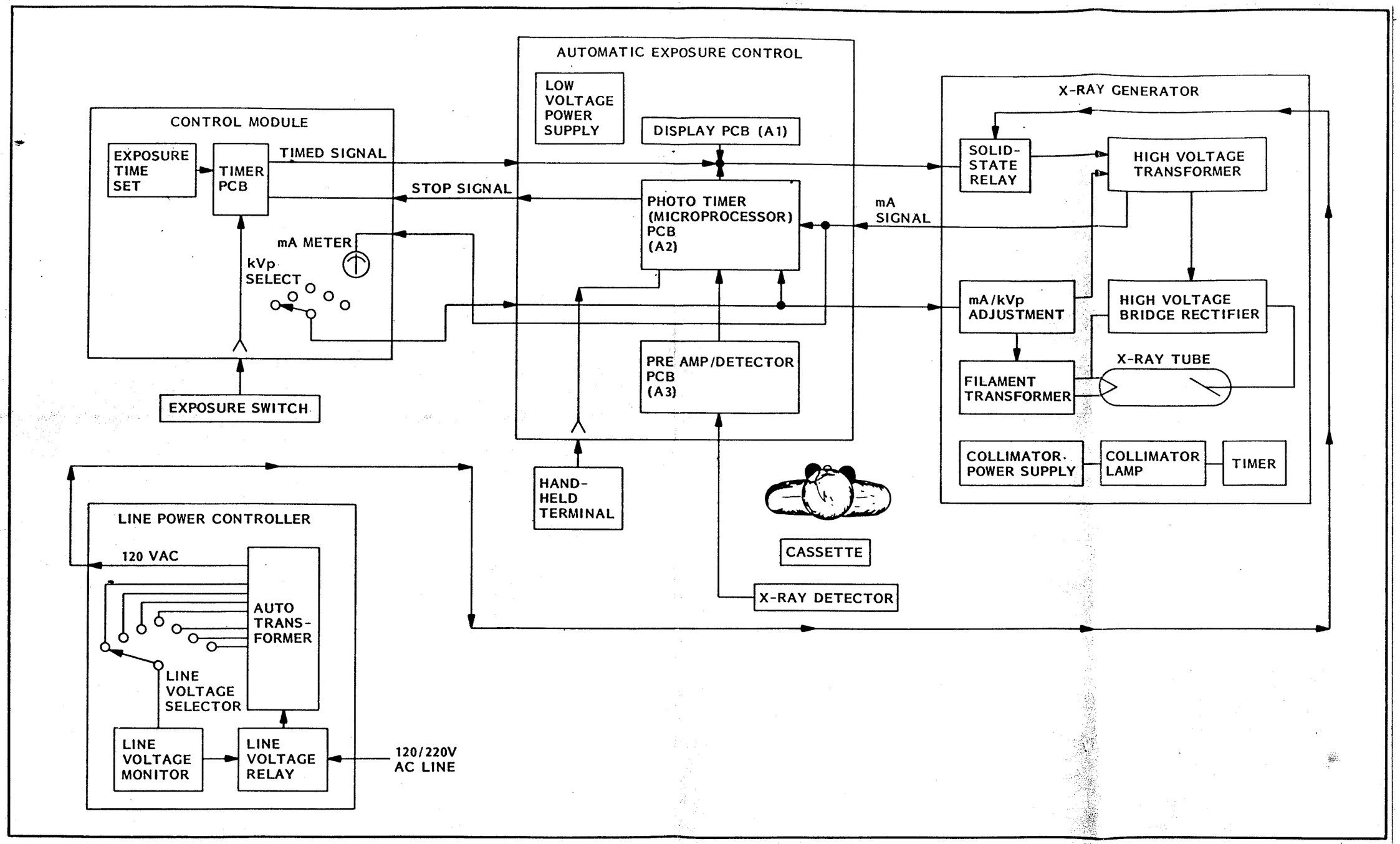


Figure 3-1. Model 9160 X-Ray System, Simplified Functional Block Diagram

The external hand-held terminal is an item of support equipment that is used to reprogram the EEproms in the microprocessor, as described in paragraph 4-16. The details of circuit functioning in the automatic exposure mode are described in the following paragraph.

3-3. Operation of The X-Ray System in Automatic Exposure Mode

The AEC works on the principle that a given amount of radiation must penetrate both the object being x-rayed and the cassette holding the film and screen, and then fall on the x-ray detector. The detector generates a voltage proportional to the radiation on it. The output of the detector is amplified and fed to the AEC. The device that receives the input from the amplifier is a voltage-to-frequency converter. The converter feeds a counter a string of pulses, the frequency of which is dependent upon the voltage received by the converter. At the start of the exposure, the counter latch is loaded with a value, called the exposure factor. When this value is decremented to zero, the exposure is complete. Each pulse from the converter decrements the counter. The counter has an output line that is activated from the time the latch is loaded until the counter reaches zero. When the counter reaches zero, the output is terminated.

The value loaded into the latch is an arbitrary number arrived at by making manual exposures during machine calibration and stored in the EEprom. It can be expressed by: Exposure Factor = Constant x Time x Voltage

The EEprom contains a table of exposure factors for up to five combinations of films, screens, and cassettes. Each combination contains a factor for the kVp from 50 to 150 in steps of 10 kVp. This base exposure factor can be modified by the operator in two ways as follows:

a. **Density Adjustment.** There are five density adjustments available on the AEC: minus 50%, minus 25%, normal (no adjustment), plus 25%, and plus 50%. The operator selects the density adjustment by means of the DENSITY Switch on the AEC front panel.

b. **Patient Size.** There are three available patient size selections: small, medium, and large. The corresponding multipliers (0.75, 1.00, and 1.25) are stored in nonvolatile memory. The operator selects the patient size adjustment by means of the SIZE (Patient) Switch on the AEC front panel.

When the operator activates the expose signal, the AEC selects the correct exposure factor from the table. If the kVp setting is between two entries in the table, the base exposure factor is interpolated. The base exposure factor is then multiplied by the density adjustment and by the patient size adjustment. The product of this multiplication is the number that is written to the counter latch for measuring the exposure. A detailed functional description of the AEC is included in paragraph 3-9 herein.

3-4. FUNCTIONAL DESCRIPTION OF X-RAY SYSTEM UNITS

The following paragraphs describe the operational function of each unit and key subassemblies in the X-Ray System. Descriptions are provided for the control module, control module timer pc board, x-ray generator, x-ray generator chassis

assembly, collimator unit, controller, AEC, x-ray sensing detector, and line power controller. Schematic diagrams included in Section 6 are referenced as required to support the descriptions.

3-5. Function of Control Module

The control module (see figure 6-2) provides operational control of all x-ray system functions in manual mode. The automatic exposure mode is controlled by the AEC unit.

The control module includes timer pc board assembly A1, which is a solid-state digital timer that provides precise exposure times without manual calibration. This pc board is described in detail in paragraph 3-6. The control module also houses kVp Meter M1, mA Meter M2, buzzer BU1, jack J1, RANGE SELECTOR rotary switch S2, POWER ON rocker switch S4, SECONDS/IMPULSES paddle switch S3, and seven LED indicators (CR1 through CR7).

3-6. Function of Control Module Timer PC Board Assembly A1

As shown in figure 6-3, primary power (120 VAC) is applied to transformer T1, the output of which is applied to diode bridge CR6 and regulator U4. The output of U4 is 5 VDC and is used throughout the timer pc board.

Primary power is also applied to the base of transistor Q7 through resistor R24. The collector of Q7 produces a 120-Hz square wave synchronous to the input line. The square wave is amplified by transistor Q6 and is connected to pin 14 of counter U1. Depending on the position of S3 (see figure 6-2), U1 will divide the frequency by 12 or by 1, producing an output clock pulse of either 1/10 second or 1/120 second (1/100 second for 50 Hz). Counter U2 is preset by thumbwheel switch S1 (EXPOSURE TIME Control) and when triggered by relay K1 it produces a pulse length equal to the number set on thumbwheel switch S1 multiplied by the clock pulse period produced by clock U1. The output is inverted by transistor Q2 and fed to inhibit timer U3 through capacitor C2, and transistor Q4 through diode CR1. Capacitor C7 is charged during the on-time of the pulse.

The trailing edge of the pulse triggers inhibit timer U3 which remains on until C7 fully discharges. In this way the inhibit time is proportional to the x-ray on-time. The output of inhibit timer U3 is connected to inverter Q3 which inverts the signal. Diodes CR1, CR3, and CR4 form a gate that requires counter U2 to be on and timer U3 to be off in order for a timed pulse to appear on the collector of transistor Q4. The circuit formed by U5, U6 and Q8, Q9, Q10 delay the operate signal by approximately 0.5 second to allow the filaments of the x-ray tube to be boosted to full output prior to the start of the timed x-ray-on cycle.

3-7. Function of X-Ray Generator

The x-ray generator produces the required x-rays. It contains three major components: a chassis assembly (P/N 5000147), a model P-180HS collimator (P/N 390007), an x-ray tube head assembly (P/N 500048). The collimator is used to restrict the x-ray beam.

The chassis assembly (see figure 6-9) contains a high-voltage transformer, a filament transformer, a high-voltage, full-wave bridge rectifier, and the S-96P x-ray tube. Three power resistors R1, R2, and R3 are used to calibrate the mA with the 30, 25, and 20 mA settings respectively on the control module panel.

Resistor R1 adjusts the current for the 60 kVp position, resistor R2 for 70 and 80 kVp positions, and resistor R3 adjusts the current for 90 and 100 kVp positions. As shown in figure 6-9, relay K1 is a solid-state relay that is normally open and closes during the x-ray-on period, thus connecting primary power to the high voltage transformer. Relay K4 closes during exposure and acts as a mechanical backup for relay K5. Diodes CR1 and CR2 form a bipolar zener regulator for the filament supply. Relays K1, K2, and K3 select transformer taps on the high voltage transformer for the proper kVp settings. Bridge circuit U1 rectifies the mA signal and test jack J5 is the test point for calibrating the mA. Transformer T1 provides 24 VAC power for the collimator lamp.

3-8. Function of Collimator

The collimator (see figure 6-10) is designed to be used with the x-ray tube to both restrict and define the area covered by the x-ray beam and to reduce stray radiation. The beam collimated by the two control knobs should cover the smallest area of the patient necessary to produce the required radiograph.

The collimator allows a stepless adjustment of a field-size x-ray and utilizes a light localizer to project a visible beam with coverage equivalent to the coverage of the x-ray beam. The calibration scales indicate the light field sizes at each SID. Accuracy is $\pm 2\%$ of SID. The collimator incorporates the following features:

- Pushbutton timer switch which, when pressed, turns on collimator light beam localizer for 30 seconds. After 30 seconds, light beam localizer automatically turns off.
- Special ring device to adjust the center of collimator by ± 2 mm to align the center of visible beam with the x-ray beam. (The collimator can be rotated.)
- Light localizer lamp is replaceable with minimal displacement error of lamp position. The lamp filament position can be easily adjusted.

3-9. Function of Automatic Exposure Control

The AEC (see figure 6-5) has the capability of making automatic exposures by measuring the radiation falling on a detector. Its operation is independent of the control module which is used to make manual exposures. The x-ray generator provides basic information to the AEC so that it can determine the proper exposure. The AEC contains display pc board assembly A1 (see figure 6-6), photo timer pc board assembly A2 (see figure 6-7), and pre amp detector pc board assembly A3 (see figure 6-8). Each switch on the AEC operating panel functions as described in the following paragraphs.

- **ON/OFF Switch**

The AEC will assert a logical "0" when the switch is turned to the ON position and a logical "1" when the switch is turned to the OFF position.

- **DENSITY Switch**

This switch is a five-position binary-coded switch for density adjustments. The closed position provides a logical "0". All other positions provide a logical "1".

- **SIZE Switch S**

This switch is a three-position binary-coded switch for patient size selection. The closed position provides a logical "0". All other positions provide a logical "1".

- **FILM SYSTEM Switch**

This switch is a five-position binary-coded switch for film selection. The closed position provides a logical "0". All other positions provide a logical "1".

- **mAs/SEC Switch**

This switch selects the display mode. It will assert a logical "0" when the display shows the exposure time in milliseconds (SEC switch position) and a logical "1" when the display shows the current-time product (mAs switch position).

- **RESET Switch**

This is a momentary switch used to reset the AEC. This switch is wired through the reset circuitry of the microprocessor. To reset the microprocessor, a momentary ground is applied by closing this switch.

The following input signals are required by the AEC:

- An x-ray radiation signal (10 volts maximum) from the x-ray detector of x-ray to be used for automatic exposure detection.
- A sample of the X-Ray System kVp signal (maximum 15 volts and in proportion to the kVp in the ratio of 1 volt per 10 kVp). The signal is filtered and smoothed so one instantaneous sample will be adequate to determine the kVp.
- A sample of the current in the x-ray tube is presented to the AEC as a 0- to 10-volt, full wave, rectified signal. Ten volts represents a current of 50 mA.
- A TTL-level signal that will be generated as soon as the current rises above noise in the x-ray tube. This signal is negative logic.

The AEC will produce the following outputs:

- A memory-mapped display refreshed with an approximately 6% duty cycle to drive the LEDs.
- An open collector output that is produced continuously except for 20 seconds following an exposure terminated normally by x-ray detector satisfaction.

3-10. AEC Operating Sequence

The AEC measures the radiation falling upon the x-ray detector and supplies a signal to turn off the x-ray tube at the end of the exposure.

When the ON/OFF switch is turned ON or the RESET button is pressed, the AEC intializes the associated units in the X-Ray System. It then performs a self-check of the program and table memories and of the random access memory (RAM). If the memory devices pass these tests, the AEC is ready to operate. If there is a test failure the fault LED on the AEC panel illuminates and the AEC will not operate.

3-11. Idle Phase

After initialization and whenever the AEC is not actively monitoring an exposure, it continuously scans the switches, measures the kVp, and computes the exposure factor.

If the automatic mode is turned off (ON/OFF switch to OFF), the display will be blank and all the LED indicators will turn off. If automatic mode is selected (ON/OFF switch to ON), the display will show, depending upon the state of the display selector, the length (in milliseconds) or the current-time product (in mAs) of the previous exposure. If no exposure has been made since selecting the automatic mode, the display will show zero. The indicator LEDs will show the termination status of the previous x-ray, if any.

3-12. Exposure Start

If the automatic mode select and the current detect lines are activated, the AEC starts an exposure measurement as follows:

- The counter latch for the detector circuit is loaded with the exposure factor.
- The counter latch for the 550 mAs safety circuit is loaded.

3-13. Exposure Monitoring

The AEC monitors exposure progress for trouble or exposure completion. Once the latches are loaded, the detector latch is monitored for 16 milliseconds. If the detector latch does not change in that time, the exposure is aborted by dropping the exposure signal, and the fault LED illuminates. The AEC must be reset before the exposure signal is activated again. While the exposure is progressing, the display is continuously updated.

3-14. Exposure Termination

Normal termination of the exposure is by detector satisfaction (sufficient radiation fell on the detector to decrement the counter to zero). The display shows either the total time of exposure or the actual current-time product of the exposure; in addition, the AUTO LED illuminates. The exposure line is deserted for twenty seconds, after which it is activated again, enabling another exposure. At the end of twenty seconds, the AUTO LED extinguishes.

If the mA present signal from the x-ray generator is terminated for 12 or more milliseconds, the GEN LED illuminates and the display shows either the time elapsed or the current-time product up to the loss of the signal. The exposure line is deserted.

If the counter for the 550 mAs safety circuit reaches zero, the GEN LED illuminates. The display shows either the time elapsed when the counter reached zero, or 550 mAs. The exposure line is deserted until the AEC is reset.

If no voltage from the x-ray detector is recorded by the AEC within 16 milliseconds of the start of an exposure, the exposure line is deserted until the AEC is reset.

3-15. X-Ray Sensing Detector Assembly

The detector assembly is a solid-state device that is attached to the rear of the X-ray film cassette with elastic straps. The detector measures the amount of radiation that passes through the patient and the cassette. The detector then routes a signal proportional to the x-rays detected to the AEC during automatic mode.

3-16. Function of Line Power Controller

The line power controller includes an auto-transformer which permits voltage selection via coil taps by means of a line voltage adjust switch. The line power controller also includes a line voltage monitor pc board and a line voltage relay. The relay connects the line for 220 V operation. If 120 V is present, the line voltage monitor pc board automatically activates the relay which switches taps on the auto transformer. Fine adjustment of the line voltage is made by the line voltage adjust switch and the meter.

SECTION 4
MAINTENANCE

4-1. INTRODUCTION

This section includes preventive maintenance, testing, troubleshooting, alignment, adjustment, replacement, and disassembly procedures for the X-Ray System. Maintenance can be performed with general-purpose tools and equipment listed in Federal Stock Catalogs or available commercially. A list of test equipment recommended is presented in table 4-1. The system is designed to permit the use of standard electronic test equipment. If any item listed in table 4-1 is not available, an equivalent item may be substituted. Troubleshooting and parts replacement instructions in this volume are limited to the modular level parts replacement and repair. Commercially-purchased units are designated as replaceable rather than repairable components. When any of these units is determined to be faulty, the user is advised to replace the unit.

Table 4-1. List of Test Equipment Recommended

Nomenclature	Model or Part Number	Manufacturer	Qty
kVp Divider	35080	Keithley	1
Digital Multimeter	245	Data Precision	1
Counter	5740	Data Precision	1
Hand-Held Terminal	HT/20	Termiflex	1
mA Test Plug	Standard Stereo Phone Plug	Commercially available	1

4-2. PREVENTIVE MAINTENANCE SCHEDULE AND PROCEDURES

The recommended preventive maintenance schedule and procedures for the X-Ray System are presented in figure 4-1. The instructions schedule includes inspection, cleaning, and lubrication procedures. Collimator preventive maintenance checks are described in paragraph 4-3.

NOTE

Films produced using the AEC should be reviewed on a weekly basis to ensure uniform operation.

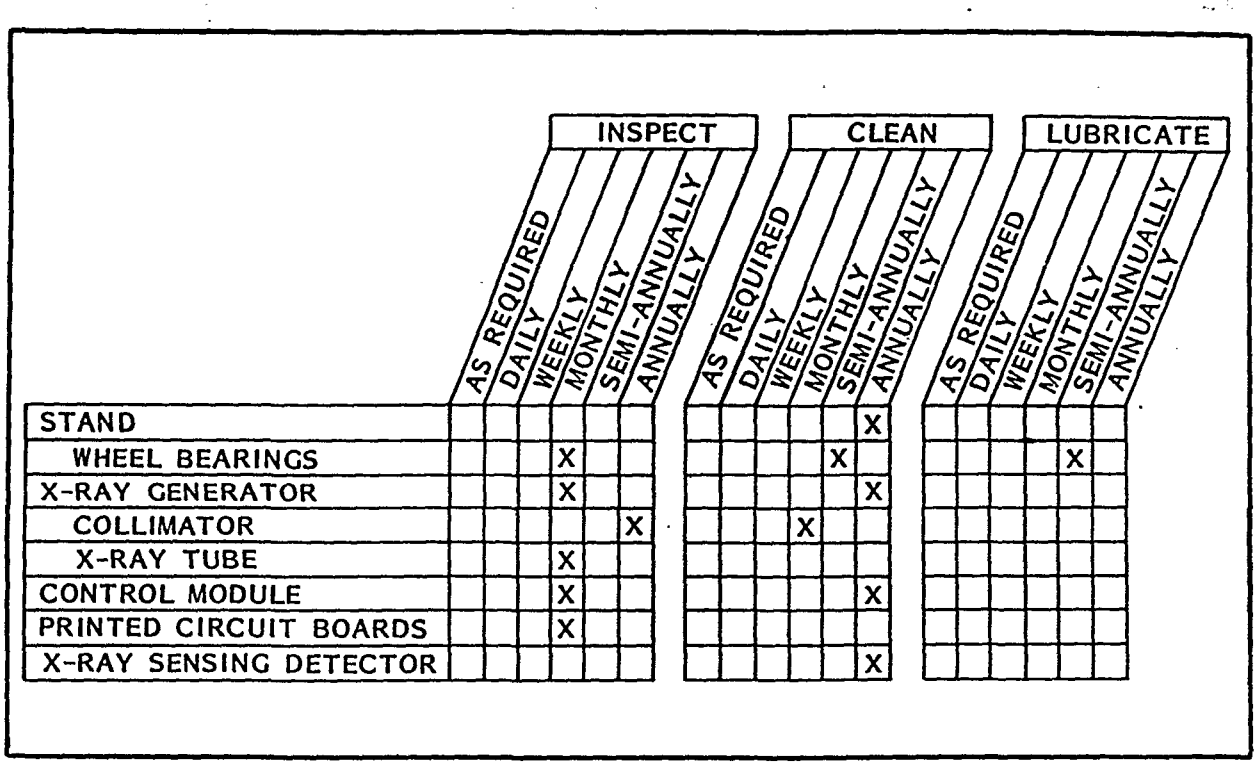


Figure 4-1. Preventive Maintenance Schedule and Procedures

4-3. COLLIMATOR PREVENTIVE MAINTENANCE

Once a year, or whenever the halogen lamp has been replaced, conduct an illuminance test to make certain that the average illuminance of the light field at SID 100 cm is 160 lux or more. If the measured illuminance is less than 160 lux, check the loading voltage line current to the lamp (see figure 6-10 for wiring diagram). If necessary, replace the lamp (refer to collimator manual); then check illuminance again to be sure that it is not less than 160 lux.

If the lamp was replaced, ensure that the centering crossmark of the collimator is aligned with the center of the light field. If the crossmark has drifted from the center of the light field, adjust the lamp filament position (refer to collimator manual) until both centers are aligned.

Once a year, or whenever the lamp has been replaced, check to be certain that the contrast ratio of the light field is 3:1 or more at SID 100 cm and that any misalignment of the light field with X-ray field is within 2% of SID. If the misalignment is more than 2% of SID, adjust the light field (target position) to within 2% of SID. (Refer to the adjustment procedure provided in the collimator manual.)

Inspect the lamp surface every month to ensure there are no fingerprints or foreign matter on the lamp. Wipe residue of any kind from the lamp. Clean all surfaces in the collimator once a month. Check the warning label to ensure that is has not been defaced and that it remains legible.

4-4. CLEANING

Use a cloth moistened in warm soapy water (mild soap) to clean the units. Do not soak the units and do not use strong cleaners or solvents as they may blur the lettering or dull the finish. To avoid scratching lens, do not polish meter windows.

4-5. TESTING

The X-Ray System operational acceptance tests are presented in this paragraph. Failure of any of these tests will be the basis for referring to the troubleshooting procedures provided in the following paragraph. To perform an operational acceptance test, complete the following tests.

4-6. System Functional Test

To perform a functional test of the X-Ray System, complete the steps presented in table 4-2.

4-7. Collimator Power Supply

Take voltage reading at collimator power supply connector (figure 6-10) with collimator plug removed. Reading at pins 1 and 3 (two upper most pins) should be 24 Vrms minimum.

4-8. Periodic Exposure Time Testing

Once every six months or 3,000 exposures, the kVp, mA, and exposure time should be tested for compliance with the specifications listed in Table 1-1 of this manual.

Beam current (mA) may be adjusted as described in paragragh 4-13 in this section. Errors in kVp or exposure time indicate a malfunction and the need for service.

4-9. TROUBLESHOOTING

If any of the operational tests described in paragraph 4-5 cannot be successfully completed, a fault is indicated. To isolate the fault, refer to table 4-3, troubleshooting guide. Once a fault has been isolated, standard tests of the outputs of each suspect module should be performed. During module testing, reference should be made to the appropriate schematic diagram in Section 6. To accelerate fault isolation, the substitution method of replacing a suspect module with an identical module known to be in good operational condition may be employed. This method is recommended for modules which can be easily replaced, such as pc boards.

Table 4-2. Functional Test of X-Ray System

Condition Established	Action	Observation	Conclusion
1. Connect X-Ray System to primary power source.	Press LIGHT switch on collimator.	Observe light pattern.	If no light pattern is observed, check the following: primary power, collimator lamp, circuit breaker CB1, transformer T1, and collimator control circuit.
2. Close collimator shutters.	a. Turn POWER ON switch to on.	a. Lamp L1 on control module should illuminate.	a. If lamp does not illuminate, check for possible faulty lamp.
	b. Observe kVp RANGE lamps on control module.	b. Lamps should illuminate.	b. If lamp(s) do not illuminate, check 5 V power supply.
	c. Observe READY lamp on control module.	c. Lamp should off initially and then illuminate in approximately 15 seconds.	c. If lamp does not illuminate, check timer pc board in control module.
	NOTE		
When checking kVp settings, exposure should terminate in 1 second. If not, check timer pc board in control module.			
3. Set kVp/mA RANGE SELECTOR to 60 kVp. Set EXPOSURE TIME to 1.0 range. Set SECONDS/IMPULSES switch to SECONDS.	Step behind screen; press Exposure Switch on remote control.	Observe the following:	
		a. X-RAY ON Indicator illuminates and buzzer sounds.	a. If indicator does not illuminate, and/or buzzer does not sound, check timer pc board on the control module.
		b. mA Meter deflects to approximately 30 mA.	b. If meter does not deflect, check x-ray generator, chassis assembly, x-ray tube, and mA Meter.

Table 4-2. Functional Test of X-Ray System - Continued

Condition Established	Action	Observation	Conclusion
		c. kVp Meter drops slightly.	c. Check primary power at input connector for poor input power regulation.
4. Set kVp RANGE SELECTOR to 80 kVp to test 80 kVp setting as done in step 3. for 60 kVp setting.	Same as step 3.	Same as step 3.	Same as step 3.
5. Set kVp RANGE SELECTOR to 100 kVp to test 100 kVp setting as done in step 3. for 60 kVp setting.	Same as step 3.	Same as step 3.	Same as step 3.

Table 4-3. Troubleshooting Guide

Malfunction	Probable Cause	Corrective Action
1. mA change by more than 5%.	X-ray tube aging.	Readjust current (refer to paragraph 4-13).
2. Excessive drop in indicated kVp upon firing of x-ray.	X-ray tube defective.	Replace x-ray tube assembly.
3. Inadequate light level or inadequate contrast ratio from collimator.	Light source aging or defective power supply.	Refer to service data for collimator power supply in Collimator Manual.
4. No collimator light.	Burned out lamp or defective collimator power supply.	Refer to service data for collimator power supply in Collimator Manual.
5. Current flow in high-voltage circuit when no exposure is being made.	Defective solid-state relay in x-ray generator.	Refer to figure 6-9, and check each relay as follows: a. Disconnect head. b. Use multimeter to check output voltage of each relay. When no exposure is made, output should be 0 volts. c. Replace any defective relay.
	Defective timer pc board in control module.	Replace timer pc board (refer to paragraph 4-19).
6. Memory failure (CRC for the program or write/read for RAM).	Defective microprocessor pc board in AEC.	Replace microprocessor pc board.
7. mAs greater than 100.	Failure of backup timer.	Replace timer pc board.

Table 4-3. Troubleshooting Guide - Continued

Malfunction	Probable Cause	Corrective Action
8. No voltage from detector was measured within 16 milliseconds of sensing of current in x-ray tube when operating in automatic mode.	a. Detector not within x-ray beam or not connected.	a. Check positioning and connection of detector; replace detector, if necessary.
	b. Malfunction in AEC unit.	b. Replace AEC unit.
9. No current was sensed within 12 milliseconds of asserting start signals.	a. Defective timer pc board.	a. Replace timer pc board.
	b. Defective solid-state relay.	b. Replace solid state relay.
	c. Defective x-ray head.	c. Replace x-ray generator.
10. Current in excess of 60 mA was measured in x-ray tube.	a. Improper mA adjustment.	a. Readjust mA.
	b. Defective high-voltage rectifier.	b. Replace x-ray generator.
	c. Defective x-ray tube.	c. Replace x-ray generator.
11. Emergency backup timer timed out.	a. Inadequate x-ray to complete exposure.	a. Use higher kVp setting.
	b. Improperly calibrated AEC.	b. Check radiation output and recalibrate AEC.
12. EEprom failed to reprogram.	Defect in microprocessor pc board.	Replace microprocessor pc board.
13. Spurious interrupt occurred.	Defect in microprocessor pc board.	Replace microprocessor pc board.

4-10. Automatic Exposure Control (AEC) Fault Conditions

There are a number of conditions under which the AEC will not operate. If one of them should occur, the AEC FAULT LED illuminates and a fault code number is displayed. The AEC then goes into an endless loop from which the only method of recovery is pushing the RESET button. The fault conditions are as follows:

- 3 - Greater than 550 mAs
- 4 - Detector test failed (no detector response)
- 5 - Greater than 10.0 seconds exposure
- 6 - Current test failed
- 7 - Bad memory
- 8 - No measured kV (Exp. factor = 0)
- 9 - EEprom failure
- 10 - Spurious interrupt.

4-11. ALIGNMENT, ADJUSTMENT, AND CALIBRATION PROCEDURES

The following paragraphs provide alignment and adjustment procedures for the X-Ray System. Alignment and adjustment of particular components will be performed in any of three situations, as required:

- To correct an operational malfunction
- Subsequent to replacement of a critical component
- Subsequent to a specified number of hours of operation.

The X-Ray System is shipped from the factory in a properly aligned and adjusted condition. Alignment or adjustment should be required only to correct a malfunction or after replacement of a major operational component.

4-12. Collimator Alignment and Adjustment

The collimator is designed and factory adjusted to ensure that the x-ray tube focus (target) position is correctly aligned with the center of the x-ray tube window. If misalignment of the light field with the x-ray field exceeds 2% of SID due to off centering of tube focus position, refer to the Collimator Manual.

WARNING

To avoid injury to inexperienced personnel, only trained and qualified personnel should be permitted access to the internal portions of the x-ray generator. Field service is limited to the following: beam current (mA), exposure time, collimator power supply and interlock, periodic testing, preventive maintenance and corrective maintenance to the module level.

4-13. Beam Current (mA)

X-ray tube current is controlled by variable resistors R1, R2, and R3 (one for each mA range) located in the x-ray generator as shown in figure 4-2. Occasional readjustment of these resistors will be required because of changes in the electron emission of the x-ray tube filament caused by tungsten evaporation as the tube ages. When the mA value as indicated on the mA Meter on the control module is more than 5% from the proper value, the resistors must be readjusted. To accomplish this, proceed as follows:

WARNING

Adjustment of power resistors must be performed with all power to X-Ray System off. Failure to turn off power could result in bodily injury to servicing personnel.

1. Remove the four screws located one in each corner of the x-ray generator cover.

2. Loosen **(do not remove)** the four screws located on each side strip (two on each side).

3. Lift off the top cover.

4. The adjustment controls (power resistors R1, R2, and R3) are located in the x-ray generator as indicated in figure 4-2.

5. Close the collimator shutters, connect the control module and power cord.

NOTE

Note the primary power must be adjusted to the value specified (120 or 220 VAC) to within plus or minus 1%.

6. Connect the mA meter to the test jack using the mA test plug.

7. Starting with the lowest kVp range, step back from the unit and operate the unit for 2 seconds. Turn the adjustment control indicated for the kVp range with a screwdriver in small increments until desired value is indicated on the mA Meter. Do not attempt to adjust the control while the unit is operating. Alternate between adjustment and operation until the correct value is indicated.

4-14. Exposure Time Adjustments

There are no adjustments for exposure time. Digital integrated circuits count each cycle or x-ray exposure and any error would indicate defective components.

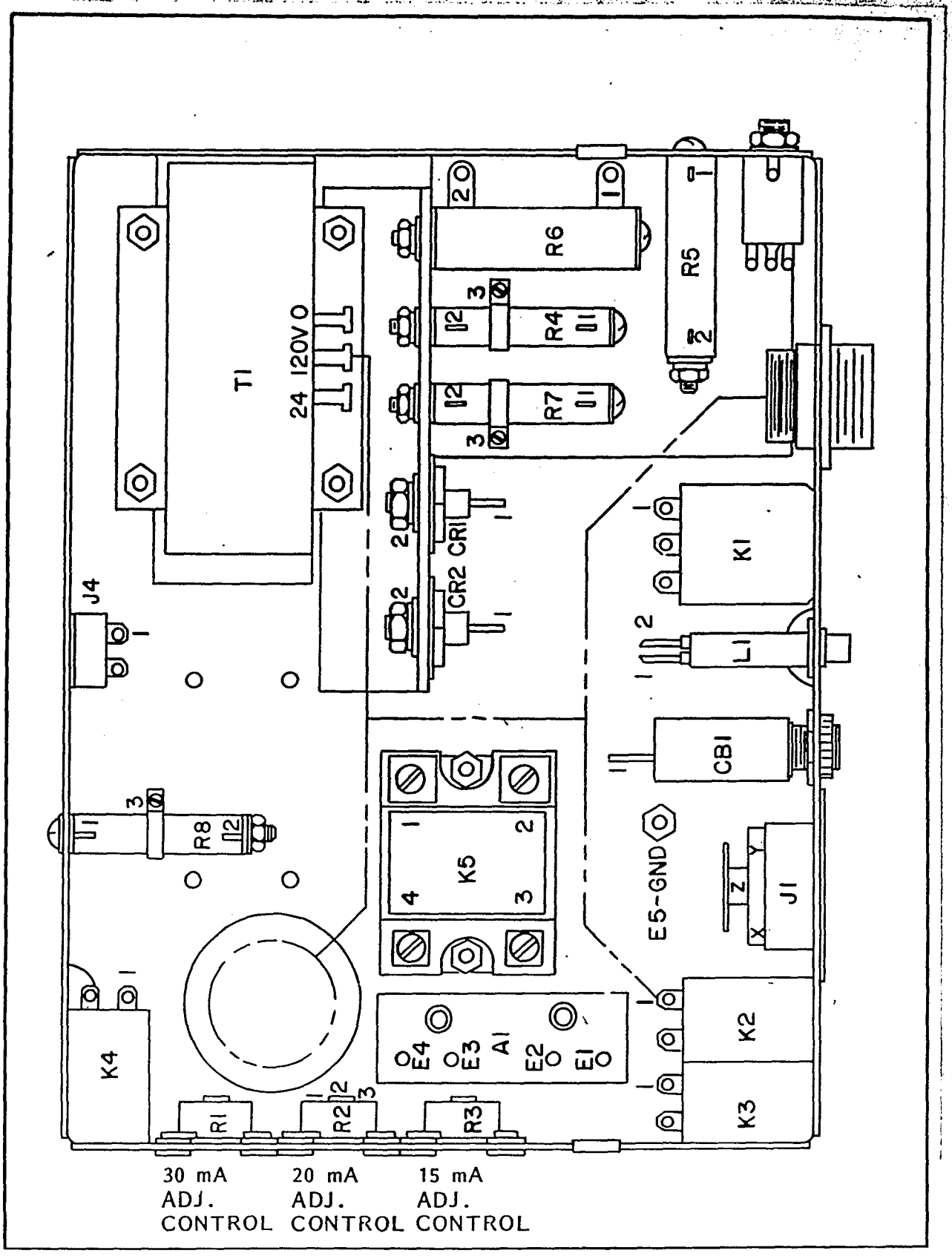


Figure 4-2. Location of Beam Current Adjustment Controls in the X-Ray Generator

4-15. Calibration of the Automatic Exposure Control (AEC)

4-16. EEprom Programming. The AEC includes a serial communications port that conforms to the RS-232 standard. It allows the AEC to communicate with an external device such as the hand-held terminal so that the AEC EEproms in the microprocessor can be reprogrammed. This feature is used for the examination and change of the exposure factor table. The data rate for communication is 300 baud. The data has eight data bits, one start bit, and one stop bit. Even parity is incorporated.

4-17. Examination and Change. The contents of the table can be written to the hand-held terminal so it may be recorded. It may also be changed by entering the new value. The method used to build the exposure factor table is outlined in the following steps:

1. The hand-held terminal is plugged into the AEC and the memory command is entered. (Type "MOD" and press RETURN key.)

2. Upon receipt of the prompt, a film/screen/cassette combination number is entered.

3. A line of digits will be displayed, for example:

   1 05 54321

   The first number is the film combination selected. The second is the kVp (50 to 150). Note that the trailing zero of the kVp is not shown because of the display line length. The third number is the base exposure factor.

4. To change the base exposure factor, key in the new value and press the RETURN key. The new value is written to the EEprom and the next table entry is displayed.

5. To examine the next table entry without changing the present value, press the RETURN Key.

6. When the end of the table is reached, the program starts over at the beginning.

7. To exit the "examine and change" task, an exit command is entered. Type "Exit" and press the RETURN key. The terminal may then be unplugged or another task selected.

4-18. REPLACEMENT AND DISASSEMBLY PROCEDURES

The following paragraphs provide instructions for parts replacement. These instructions are limited to those parts for which replacement procedures are not obvious. Where disassembly is required, a disassembly procedure is included. If required, the associated parts location diagram in Section 5 is referenced. Where necessary, references are made to numbered callouts on the parts location diagram to support the disassembly procedure. In those instances where parts replacement is not the reverse of the removal procedure, specific replacement procedures are included.

4-19. Removal and Replacement of X-Ray Generator Collimator, Chassis, and Connector Components

1. Remove the four screws located one in each corner of the x-ray generator top cover.

2. Loosen (do not remove) the four screws located on each side strip (two on each side).

3. Lift off the top cover.

4. Replace defective component.

NOTE

If the chassis assembly or the collimator assembly are replaced, refer to paragraphs 4-11, 4-12, and 4-13 for calibration procedures.

5. Replace generator cover and secure with four corner screws. Tighten four side strip screws.

4-20. Removal and Replacement of Tube Head Assembly

1. Remove the four screws located one in each corner of the x-ray generator bottom cover.

2. Loosen (do not remove) the four screws located on each side strip (two on each side).

3. Lift off the bottom cover.

4. Replace defective tube head asembly.

5. Perform calibration procedures listed in paragraphs 4-11, 4-12, and 4-13.

6. Replace bottom cover and secure with four corner screws. Tighten four side strip screws.

SECTION 5
PARTS LIST

5-1. INTRODUCTION

This section contains a list of recommended replacement parts for the X-Ray System. The parts list for the complete X-Ray System is presented in table 5-1, with a supporting parts location diagram, figure 5-1. Tables 5-2 through 5-12 and parts location diagrams, figures 5-2 through 5-12, are included for each of the major assemblies and subassemblies. Table 5-1 contains four columns as follows: Section 5 figure and part index number, part description, part number, and quantity per unit. Subassembly parts location diagrams are referenced in the description column when a detailed breakdown is provided. Tables 5-2 through 5-12 contain the same four columns used for table 5-1. Available details of parts configurations for the commercially-purchased units are included in the associated commercial manual supplement, as applicable.

Table 5-1. Model 9160M X-Ray System Parts List

Figure & Index No.	Description	Part Number	Qty Per Unit
5-1	MODEL 9160M X-RAY SYSTEM		
1	o X-RAY STAND ASSEMBLY (see figure 5-2)	500180	1
2	o CONTROL MODULE (see figure 5-8)	500151	1
3	o X-RAY GENERATOR (see figure 5-9)	500154	1
4	o AUTOMATIC EXPOSURE CONTROL 9160 (see figure 5-11)	500225	1
5	o Line Power Controller (see figure 5-12)	500258	1
6	o CABLE (Automatic Exposure Control to X-Ray Generator)	500251	1
7	o CABLE (Line Power Controller to X-Ray Generator)	500255	1
8	o LINE CORD	500254	1

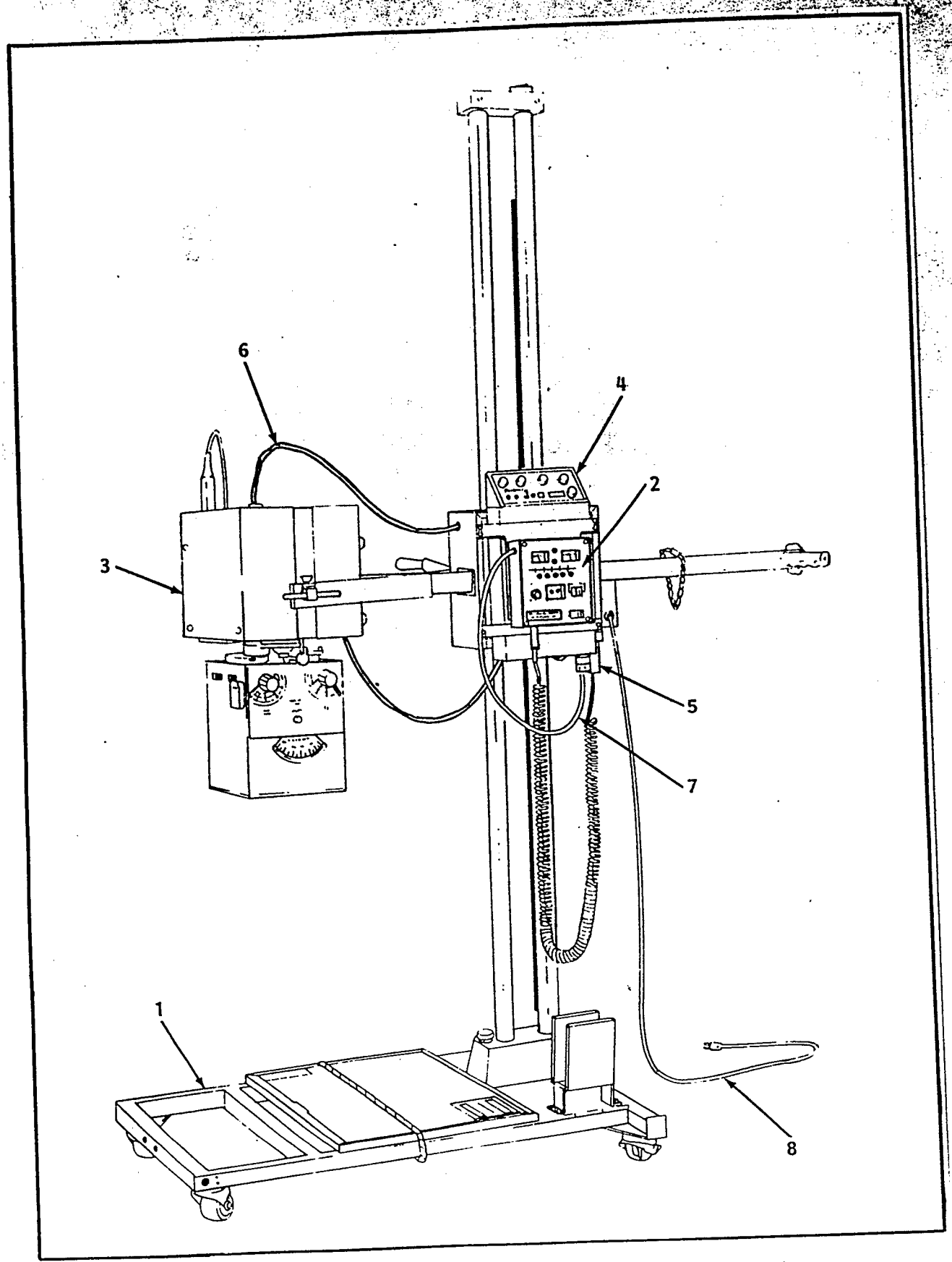


Figure 5-1. Model 9160M X-Ray System Parts Location Diagram

Table 5-2. X-Ray Stand Assembly Parts List

Figure & Index No.	Description	Part Number	Qty Per Unit
5-2	X-RAY STAND ASSEMBLY, 400TB	500180	1
1	o BASE ASSEMBLY (see figure 5-3)	500176	1
2	o GEAR BOX ASSEMBLY (see figure 5-4)	500023	1
3	o VERTICAL TUBE ASSEMBLY (see figure 5-5)	500026	1
4	o CROSS BAR ASSEMBLY (see figure 5-6)	500028	1
5	o YOKE ASSEMBLY (see figure 5-7)	500042	1
	*** ATTACHING PARTS ***		
	o o KEEPER	--	4
	o o NUT, 1/4-20 Low Profile	382018	2
	o o SCREW, Pan Head, No. 6-32x5/8	380526	2
	o o SCREW, Pan Head, No. 8-32x5/8	381111	10
	o o SCREW, Pan Head, No. 10-32x5/8	381505	20
	o o WASHER, Flat, No. 6	MS15795-805	2
	o o WASHER, Flat, No. 8	MS15795-807	10
	o o WASHER, Flat, No. 10	MS15795-808	20
	o o WASHER, Lock, No. 6	MS35338-136	2
	o o WASHER, Lock, No. 8	MS35338-137	10
	o o WASHER, Lock, No. 10	MS35338-138	20
	o o NUT, Plain, No. 6-32	380500	2
	o o NUT, Plain, No. 8-32	381000	10
	o o NUT, Plain, No. 10-32	381500	12

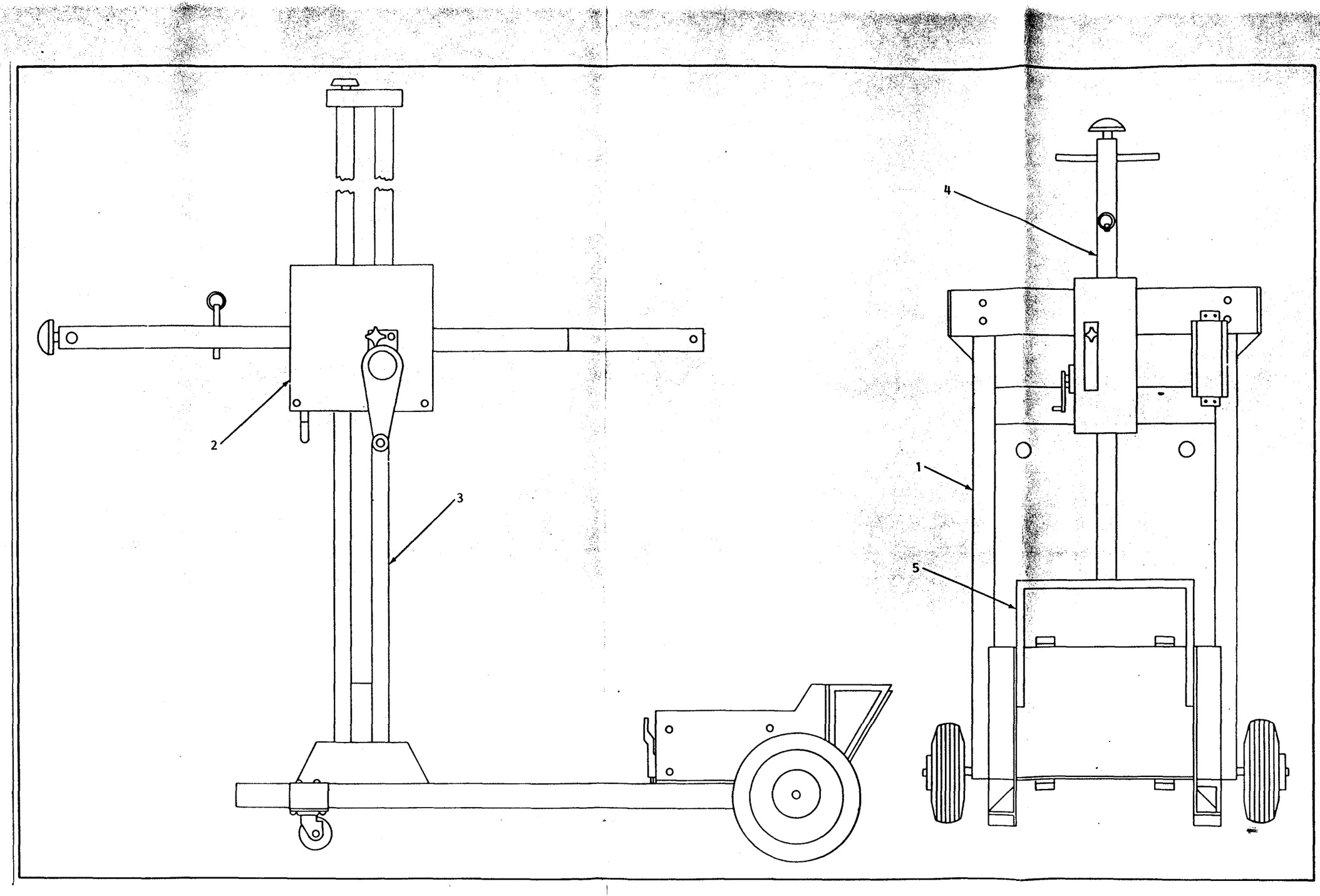


Figure 5-2. X-Ray Stand Assembly
Location of Assemblies

Table 5-3. Base Assembly Parts List

Figure & Index No.	Description	Part Number	Qty Per Unit
5-3	BASE ASSEMBLY	500176	1
1	o BASE SUBASSEMBLY (see detail A)	500175	1
2	o o BASE WELDMENT	100472	1
3	o o HANDLE	100482	1
4	o o BRONZE BEARING	384136	2
5	o o HELI-COIL, 3/8(.3750)-16	384211	2
	*** ATTACHING PARTS ***		
	o o o SCREW, Flat Head, 1/4-20x 1-1/2, 82°	382033	4
	o o o WASHER, Flat, 1/4	MS15795-80	4
	o o o CAPNUT, 1/4-20	382022	4
6	o WHEEL ASSEMBLY (see detail B)	500176	2
7	o o AXEL	100473	2
8	o o WHEELCAP	100339	2
9	o o SEMI-PNEUM, 10-in. wheel	390126	2
10	o o RETAINING RING, 5/8	384210	4
	*** ATTACHING PARTS ***		
	o o o SCREW, Cap, 1/4-20x9/16	382027	2
	o o o WASHER, Flat, 1/4	MS15795-80	2
	o o o WASHER, Lock, 1/4	MS35338-139	2
11	o CONTAINER HEAD ASSEMBLY (see detail C)	500177	1
12	o o HEAD CONTAINER	100484	1

Table 5-3. Base Assembly Parts List - Continued

Figure & Index No.	Description	Part Number	Qty Per Unit
5-3 - Continued			
13	o o HOLDING BRACKET L/S	100477	1
13A	o o HOLDING BRACKET R/S	100492	1
14	o o CHOCK	100480	1
15	o o HANGER	100478	1
16	o o COVER	100483	1
17	o o FRONT CUSHION	100486	2
17A	o o CUSHION REAR	100486	1
18	o o SIDE CUSHION	100488	1
19	o o BOTTOM CUSHION	100489	1
20	o o CUSHION COVER	100490	1
	*** ATTACHING PARTS ***		
	o o o 'U' CHANNEL GROMMET	390132	19"
	o o o LATCH AND KEEPER	384212	4
	o o o PAD CHOCK	100494	2
	o o o SCREW, Pan Head, No. 6-32x12	380503	6
	o o o SCREW, Pan Head, No. 8-32x1/2	381004	20
	o o o BOLT, Hex Head, 1/4-20x5/8	382016	4
	o o o WASHER, Flat, No. 6	MS15795-805	6
	o o o WASHER, Flat, No. 8	MS15795-807	24
	o o o WASHER, Flat, 1/4	MS1595-800	7
	o o o WASHER, Lock, No. 6	MS35338-136	6

Table 5-3. Base Assembly Parts List - Continued

Figure & Index No.	Description	Part Number	Qty Per Unit
5-3 - Continued			
	o o o WASHER, Lock, No. 8	MS35338-137	20
	o o o WASHER, Lock, 1/4	MS35338-138	4
	o o o NUT, Plain, 1/4-20	382000	3
	o o o NUT, Plain, No. 6-32	380500	6
	o o o NUT, Plain, No. 8-32	381000	20
21	o JACK STAND ASSEMBLY	500167	1
22	o o CHANNEL	100474	1
23	o o LEG	100475	1
	*** ATTACHING PARTS ***		
	o o o SPACER, Round, No. 8-32, 63/64 Lg x .25 O.D.	383544	2
	o o o SCREW, Pan Head, No. 8-32x1/2	381004	4
	o o o WASHER, Flat, No. 8	MS15795-807	4
	o o o WASHER, Flat, No. 8, .178 I.D. x .562 O.D. x .187 Thk	383058	2
	o o o WASHER, Lock, No. 8	MS35338-137	4
24	o VERTICAL TUBE ASSEMBLY HOLDER	100476	1
25	o RUBBER CUSHION	100481	1
26	o RUBBER STRIP	100491	2
27	o MODIFIED COMPONENT HOLDER	100495	1
28	o END CAP	100497	2
29	o SWIVEL WHEEL	390142	2

Table 5-3. Base Assembly Parts List - Continued

Figure & Index No.	Description	Part Number	Qty Per Unit
5-3 - Continued			
30	o LOCKING SWIVEL WHEEL	390143	2
31	o HAND RETRACTABLE PLUNGER	383040	2
32	o BASE ASSEMBLY DUST COVER	384218	1
33	o ELASTIC TIE DOWN CORD	384220	1
	*** ATTACHING PARTS ***		
	o o NUT, 1/4 - 20 LOW PROFILE	382018	2
	o o SCREW, Pan Head, No. 6-32x5/8	380526	2
	o o SCREW, Pan Head, No. 8-32x5/8	381111	10
	o o SCREW, Pan Head, No. 10-3x5/8	381505	20
	o o WASHER, Flat, No. 6	MS15795-805	2
	o o WASHER, Flat, No. 8	MS15795-807	10
	o o WASHER, Flat, No. 10	MS15795-808	20
	o o WASHER, Lock, No. 6	MS35338-136	2
	o o WASHER, Lock, No. 8	MS35338-137	10
	o o WASHER, Lock, No. 10	MS35338-138	20
	o o NUT, Plain, No. 6-32	380500	2
	o o NUT, Plain, No. 8-32	381000	10
	o o NUT, Plain, No. 10-32	381500	12

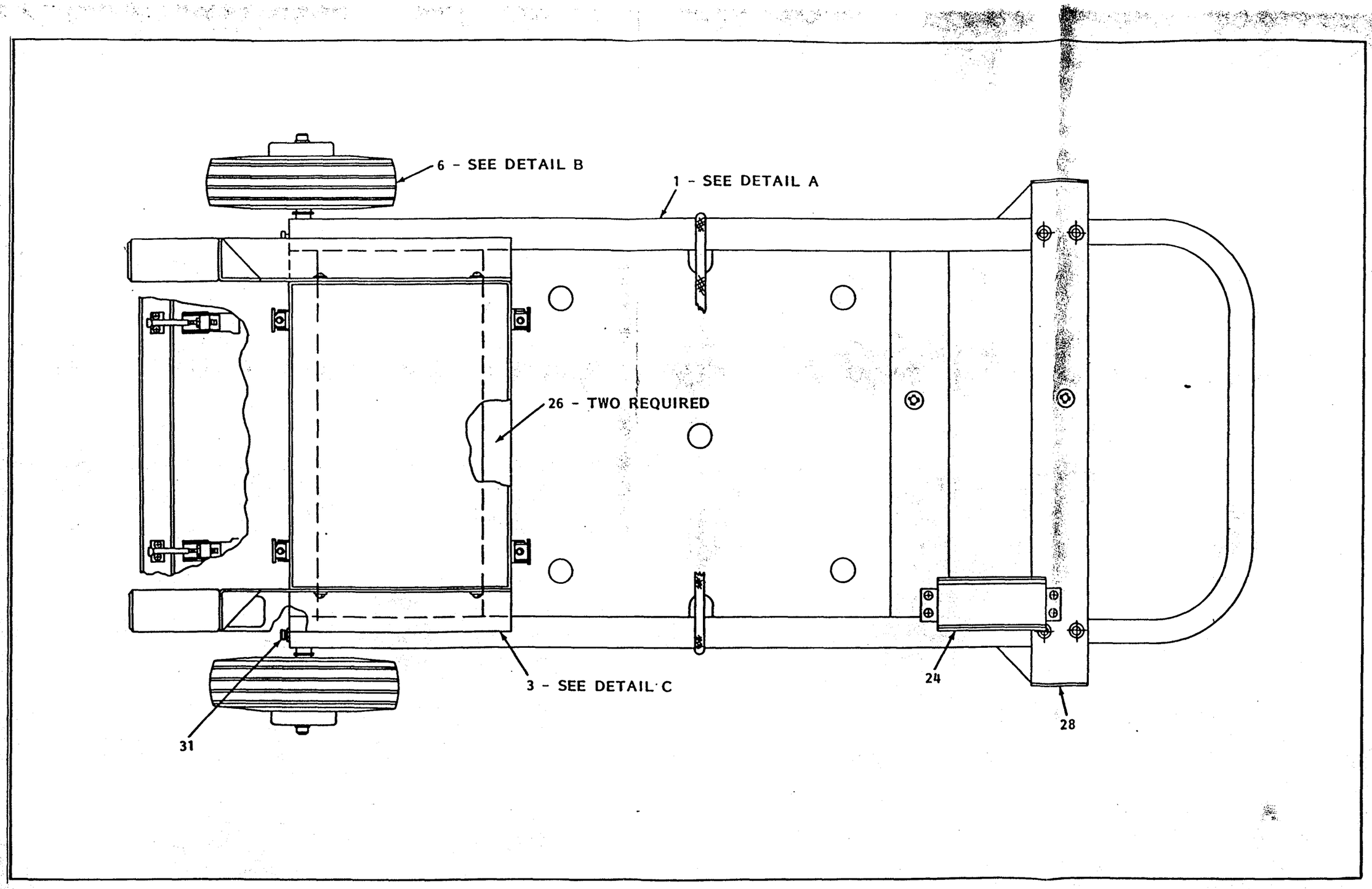


Figure 5-3. Base Assembly, Top View, Location of Components (Sheet 1 of 5)

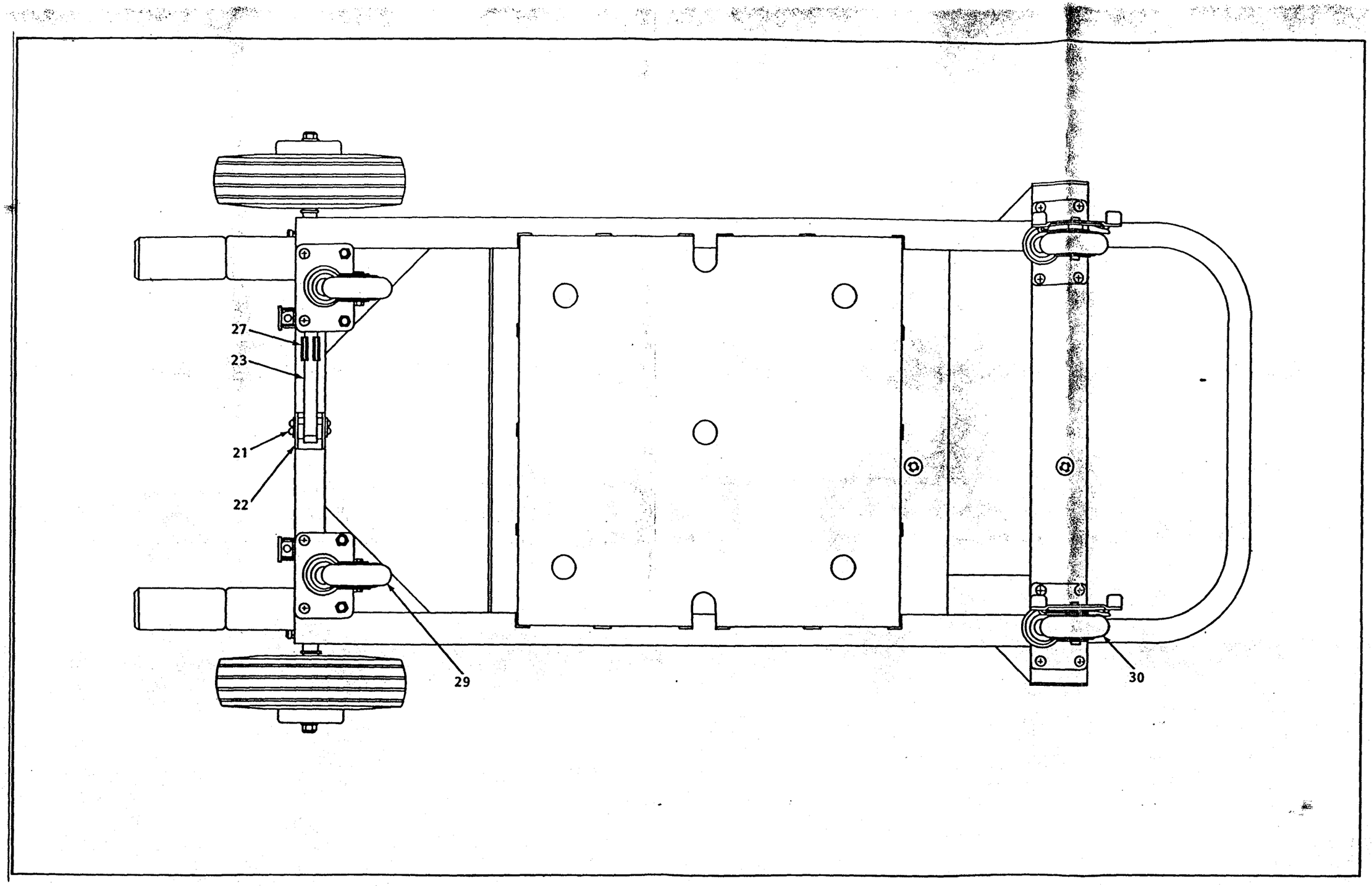


Figure 5-3. Base Assembly, Top View, Location of Components (Sheet 2 of 5)

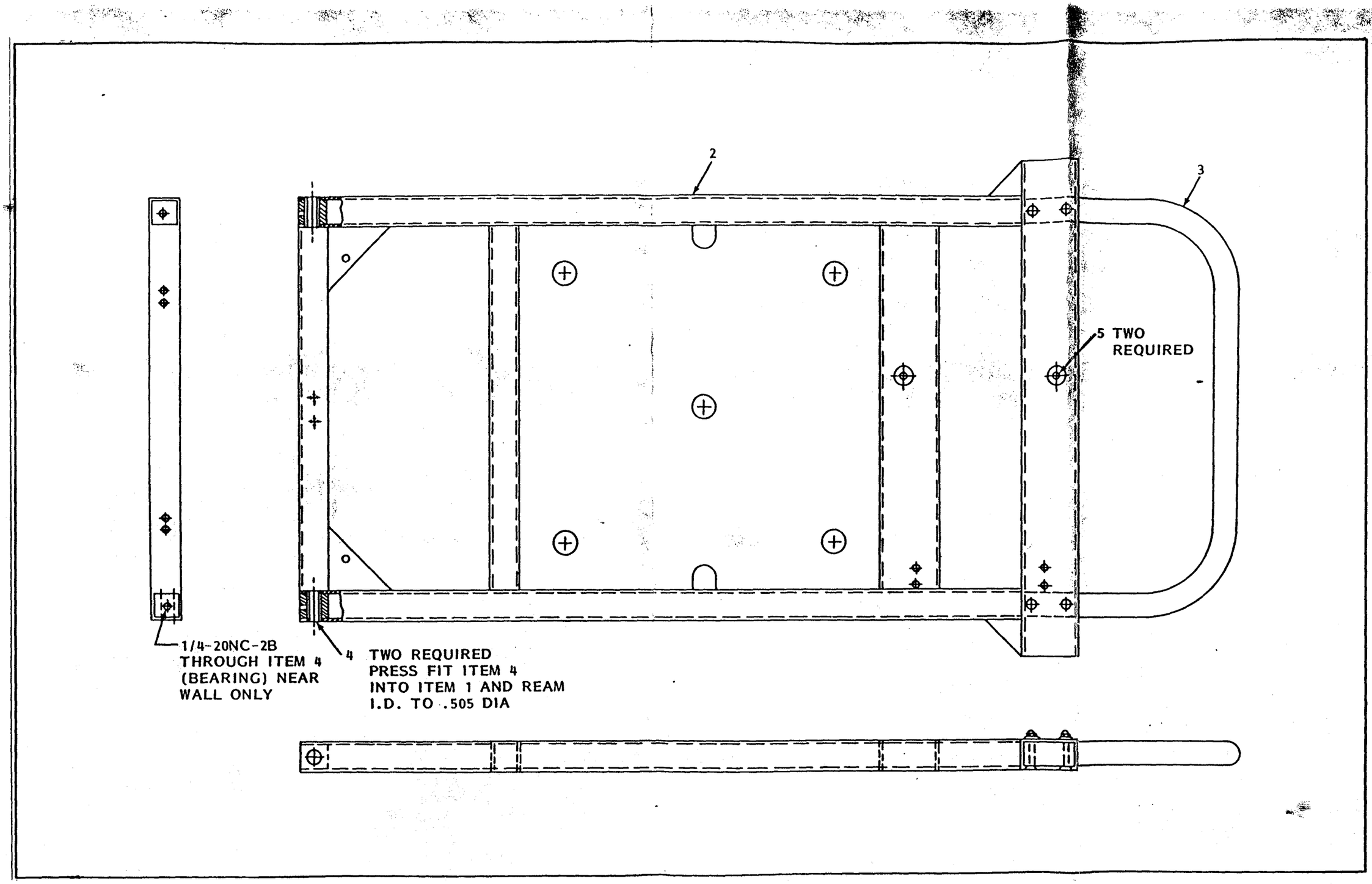


Figure 5-3. Base Assembly, Top View, Location of Components (Sheet 3 of 5)

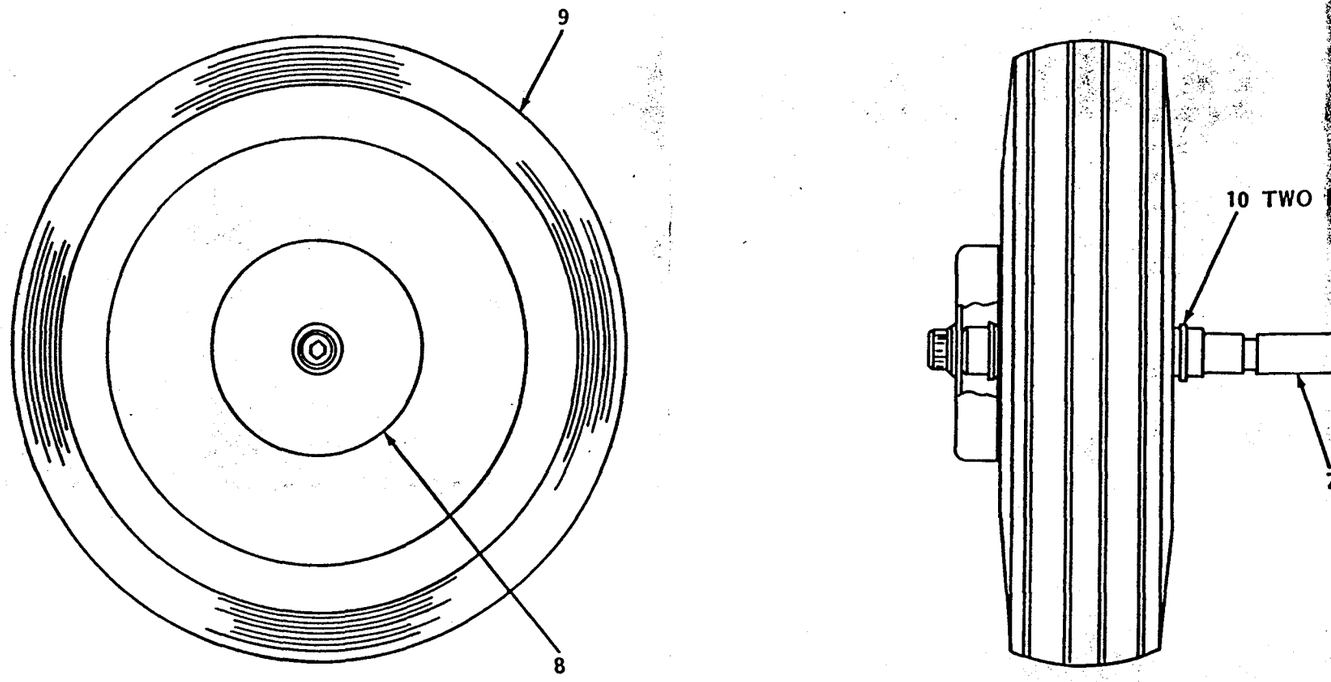


Figure 5-3. Base Assembly, Top View, Location of Components (Sheet 4 of 5)

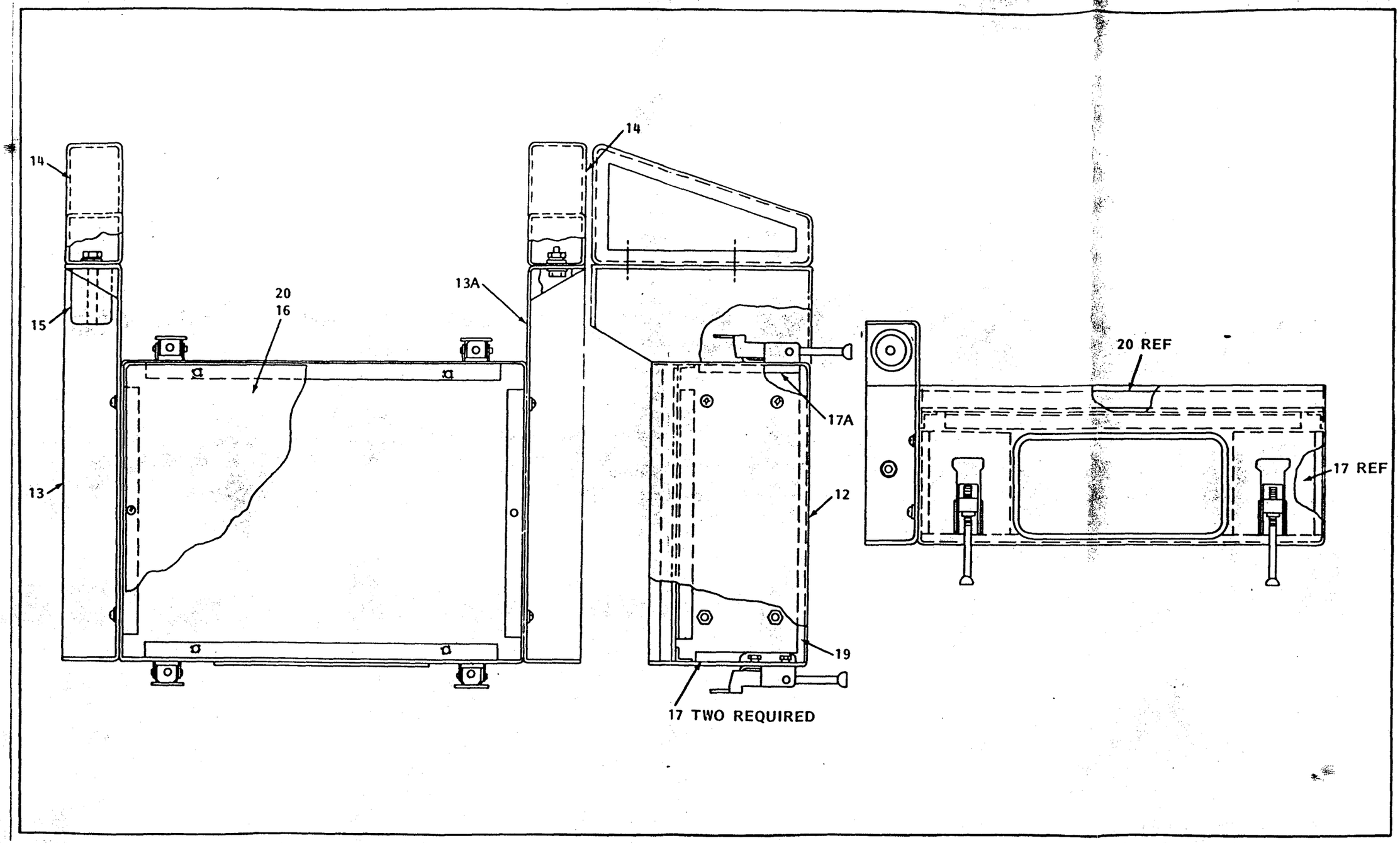


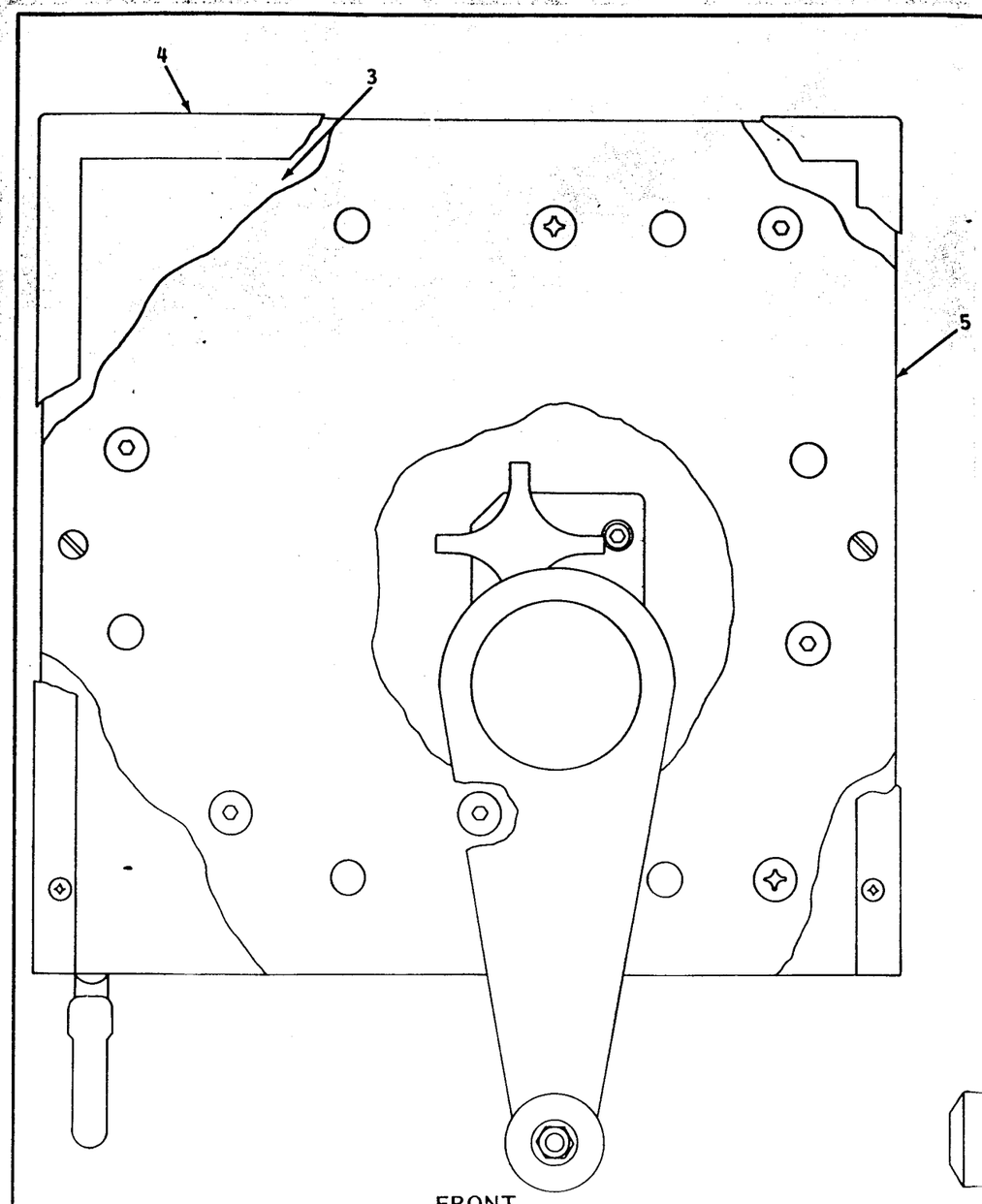
Figure 5-3. Base Assembly, Top View, Location of Components (Sheet 5 of 5)

Table 5-4. Gear Box Parts List

Figure & Index No.	Description	Part Number	Qty Per Unit
5-4	GEAR BOX ASSEMBLY	500023	1
1	o CRANK HANDLE ASSEMBLY	500024	1
2	o CONTROL BLOCK ASSEMBLY	500049	1
3	o FRONT/SIDE COVER	100055	1
4	o FRAME COVER	100056	1
5	o FRONT PLATE	100100	1
6	o BACK PLATE	100101	1
7	o HORIZONTAL GUIDE SHAFT	100102	2
8	o VERTICAL GUIDE SHAFT	100102	2
9	o GEAR CLUSTER SHAFT	100105	1
10	o HORIZONTAL ROLLER SHAFT	100106	2
11	o ECCENTRIC SHAFT BEARING	100116	2
12	o LOCK PAD	100119	1
13	o VERTICAL GUIDE ROLLER	100122	2
14	o ARM LOCK BRAKE PLATE	100123	1
15	o BACK COVER	100254	1
16	o CLUSTER GEAR	100108	1
17	o HOOK	384000	1
18	o BALL BEARING	384023	2
19	o NEEDLE BEARING	384022	4
20	o OILITE BEARING	384136	1

Table 5-4. Gear Box Parts List - Continued

Figure & Index No.	Description	Part Number	Qty Per Unit
5-4 - Continued			
	*** ATTACHING PARTS ***		
	o o SCREW, Socket Head, 10-24x1-3/16 Lg	381503	2
	o o SCREW, Socket Head, 10-24x1 Lg	381510	1
	o o BEARING SPACER	100205	2
	o o BOLT, Hex Head, Nylon, 3/8-16x1/2 Lg (rework)	100391	2
	o o WASHER, Lock, 1/4	382002	2
	o o SCREW, Shoulder, No. 6-32	383055	4
	o o WASHER, Nylon 1 O.D. x 9/16 I.D. x 1/8 Thk	383014	2
	o o SPRING	384017	2
	o o FASTENER, No. 8-32	383003	2
	o o RETAINING RING, External, 1/2	384026	3
	o o BOLT, Hex Head, Nylon, 3/8-16x1/2 Lg	382513	4
	o o SCREW, Socket, Flat Head, 1/4-20x 5/8 Lg	382004	12
	o o SCREW, Socket, Flat Head, 1/4-20x 1-3/4 Lg	382003	2
	o o WASHER, Flat, 3/8	382501	4
	o o SCREW, Pan Head, No. 6-32x3/16 Lg	380506	6
	o o SCREW, Flat Head, Sheet Metal, 8A x 5/8 Lg	383007	2
	o o SCREW, Socket Head, 1/4-20x3/8 Lg	382006	2



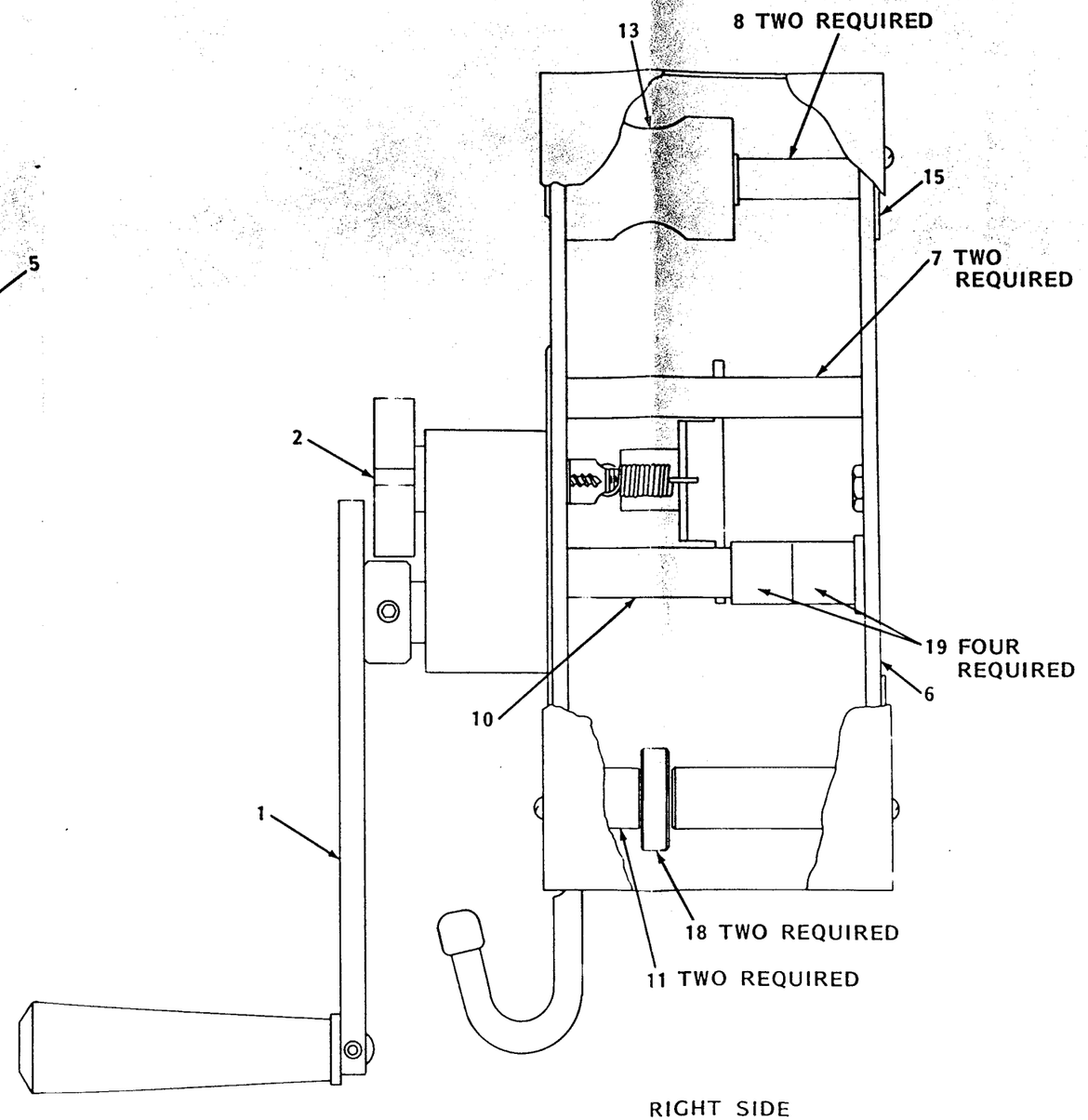
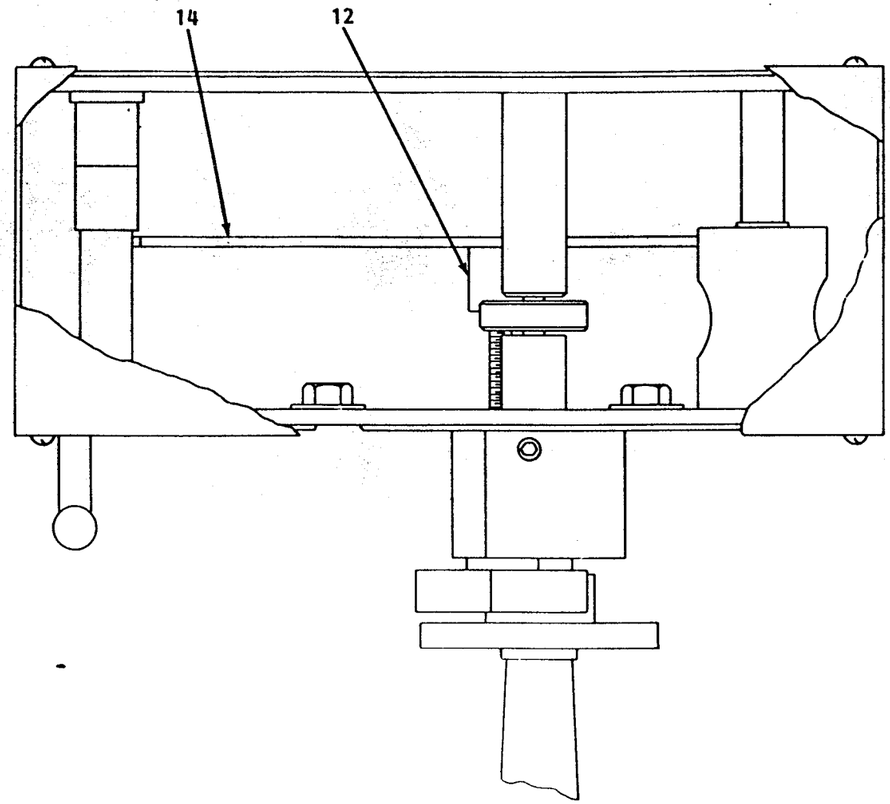
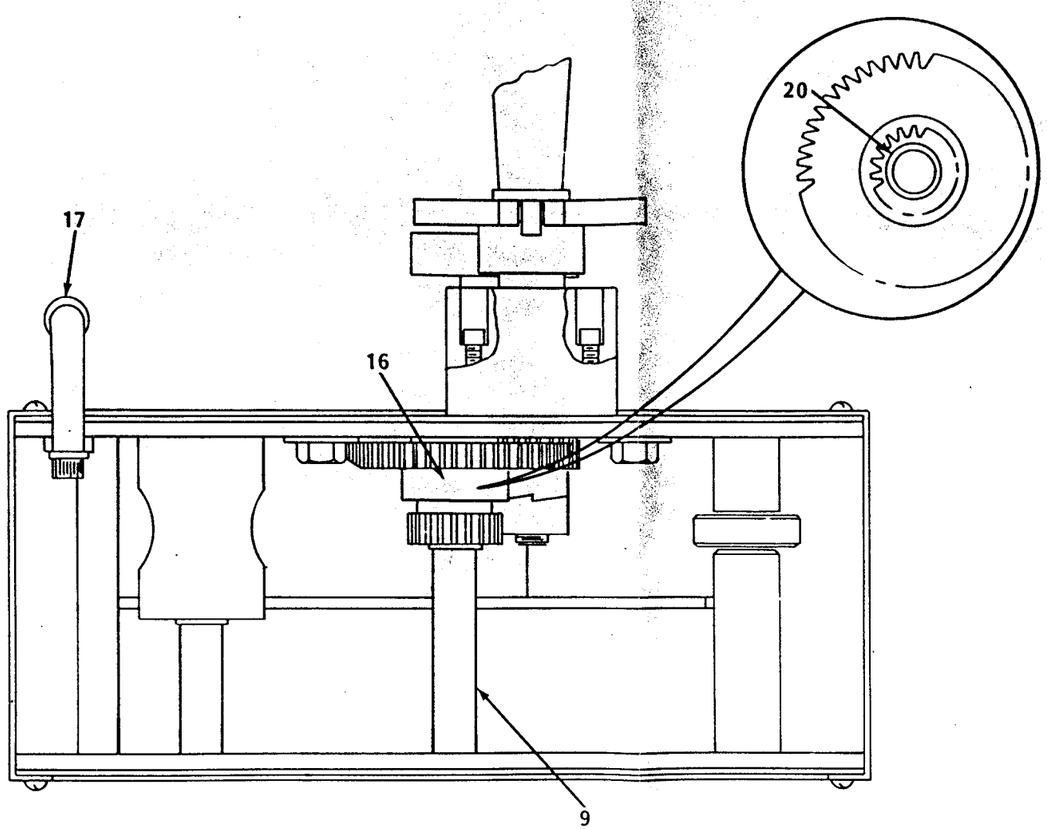


Figure 5-4. Gear Box Assembly (500023) Location of Components (Sheet 1 of 2)



TOP VIEW



BOTTOM VIEW

Figure 5-4. Gear Box Assembly (500023)
Location of Components (Sheet 2 of 2)

Table 5-5. Vertical Tube Assembly Parts List

Figure & Index No.	Description	Part Number	Qty Per Unit
5-5	VERTICAL TUBE ASSEMBLY	100476	1
1	o TOP GUIDE BLOCK	100129	1
2	o BOTTOM GUIDE BLOCK	100128	1
3	o VERTICAL TUBE SUBASSEMBLY	500158	1
4	o VERTICAL TUBE & RACK SUBASSEMBLY	500157	1
5	o DRAW BOLT	100125	1
6	o DRAW BOLT BLOCK	100124	1
7	o KNOB	384030	1
8	o ROLL PIN, .31 Dia x 2.25 Lg	383509	4
9	o ROLL PIN, .06 Dia x .75 Lg	383505	1
10	o CENTERING PLATE	100469	1

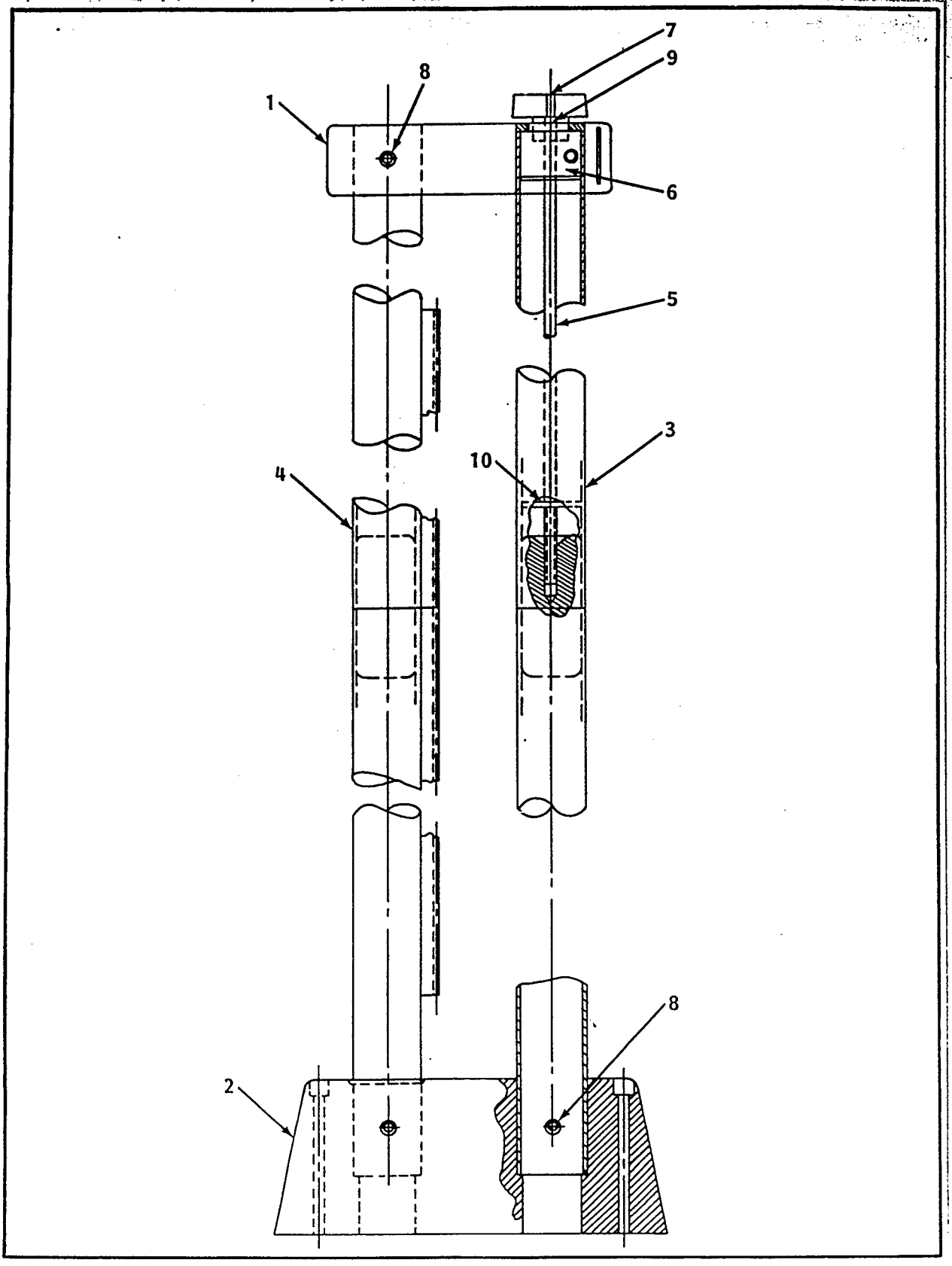


Figure 5-5. Vertical Tube Assembly Location of Components

Table 5-6. Cross Bar Assembly Parts List

Figure & Index No.	Description	Part Number	Qty Per Unit
5-6	CROSS BAR ASSEMBLY	500028	1
1	o CROSS BAR, 34-1/2, 1.5x1.5x14 Ga.	100136	1
2	o HANDLE	100138	1
3	o GUIDE	100139	2
4	o HANDGRIP, White	390019	2
5	o KNOB	384014	1
6	o PIN	383512	1
7	o THREADED ROD, 3/8-16x31-1/2 in.	384170	1
8	o CHAIN, Small Link, 10 in.	384169	1
	*** ATTACHING PARTS ***		
	o o SET SCREW, 1/4-20x1/4 Lg	382005	2
	o o SCREW, Flat Head, Socket, 1/4-20x 5/8	382004	1
	o o NUT, Hex, 3/8-16	382500	4

Table 5-8. Control Module Parts List

Figure & Index No.	Description	Part Number	Qty Per Unit
5-8	CONTROL MODULE	500151	1
1	o CASE ASSEMBLY	500138	1
2	o o PC BOARD ASSEMBLY, 1160 TIMER	500140	1
3	o o CASE	100394	1
4	o o MOUNTING PLATE	100390	1
5	o o BUZZER	390023	1
6	o o HOOK	384085	1
	*** ATTACHING PARTS ***		
	o o o NUT, No. 4x40	380000	2
	o o o SCREW, Flat Head, 6-32x1/4 Lg	380529	9
7	o PANEL TIMER ASSEMBLY	500150	1
8	o o PANEL	100393	1
9	o o ROTARY SWITCH	370041	1
10	o o ROCKER SWITCH	370015	1
11	o o PADDLE SWITCH	370033	1
12	o o LED, Red	390060	6
13	o o LED, Green (Ready)	390061	1
14	o o kVp METER	374001	1
15	o o mA METER	374002	1
16	o o RESISTOR, Variable, 250 K,	345005	1
17	o o KNOB, Plain, 1/8 Shaft	390119	
18	o o RESISTOR, Carbon, 43, K 1/4W $\pm$5%	340025	1

Table 5-8. Control Module Parts List - Continued

Figure & Index No.	Description	Part Number	Qty Per Unit
5-8 - Continued			
19	o o RESISTOR, Carbon, 20 K, 1/4W ±5%	340021	1
20	o o RESISTOR, Carbon, 24 K, 1/4W ±5%	340082	1
21	o o RESISTOR, Carbon, 33 k, 1/4W ±5%	340067	1
22	o o SIGNAL DIODE	300002	1
23	o HAND CONTROL ASSEMBLY (Exposure Switch)	500163	1
24	o 12-PIN CONNECTOR PLUG	385084	1
25	o PIN, Male	385086	12
26	o BOOT	385088	1
27	o GRIP	385089	1
28	o STRAIN RELIEF	384090	1
29	o HARNESS ASSEMBLY	500164	1
	*** ATTACHING PARTS ***		
	o o SCREW, Pan Head, No. 6-32x1/4 Lg		4

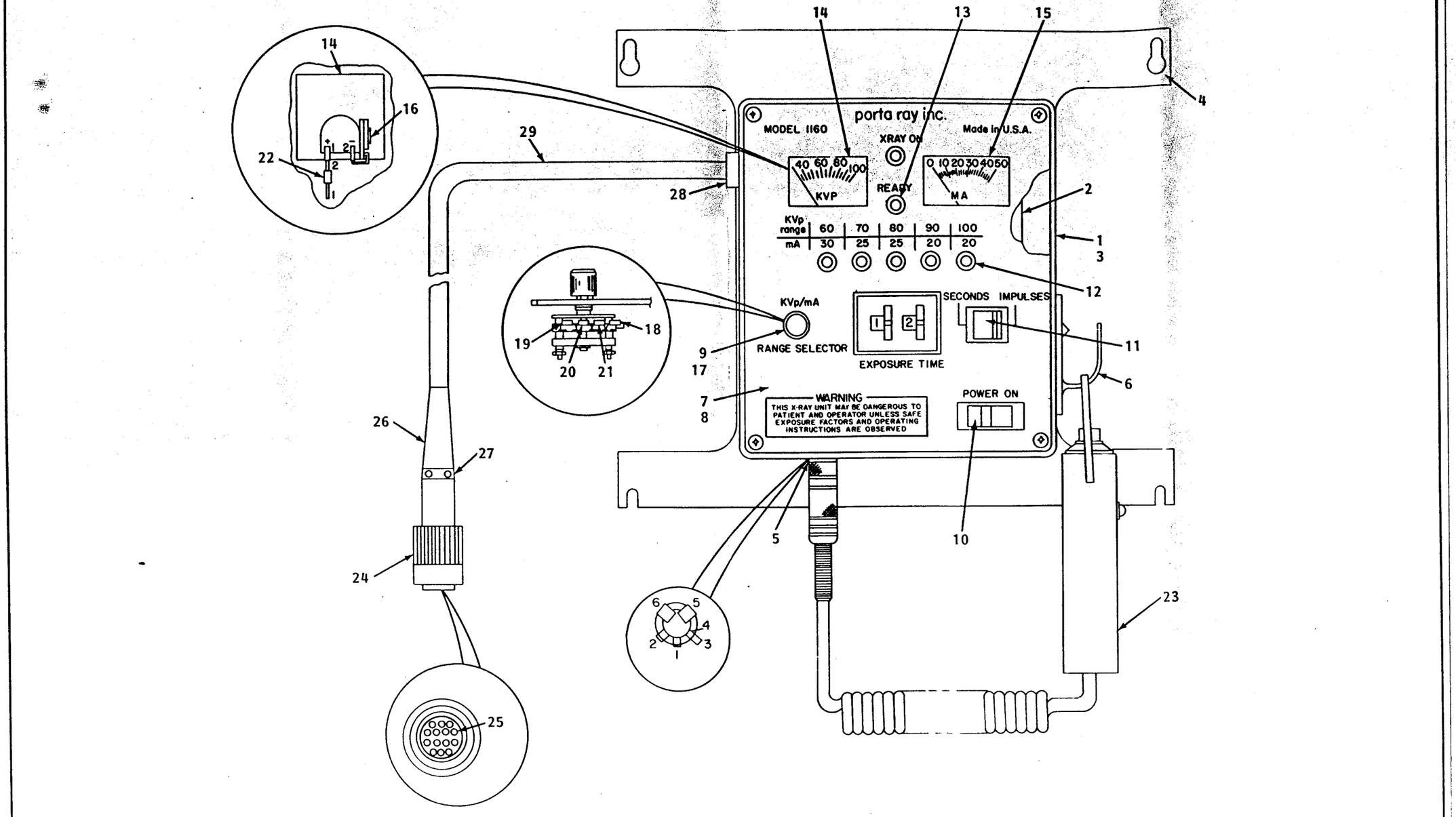


Figure 5-8. Control Module
Location of Components

Table 5-9. X-Ray Generator Parts List

Figure & Index No.	Description	Part Number	Qty Per Unit
5-9	X-RAY GENERATOR	500154	1
1	o CHASSIS ASSEMBLY (see figure 5-10)	500147	1
2	o TUBE HEAD ASSEMBLY	500048	1
3	o COLLIMATOR ASSEMBLY	390007	1
4	o FRONT PANEL	100042	1
5	o REAR PANEL	100043	1
6	o TAPE MEASURE	390049	1
7	o SIDE COVER BAR	100037	2
8	o HANDLE	100035	2
9	o SUPPORT ROD	100036	4
10	o COVER	100040	2
11	o MAIN FRAME SIDE BAR	100058	2
12	o LINE CORD ASSEMBLY (see Detail A)	500139	1
13	o o CONNECTOR, Female	385013	1
14	o o CONNECTOR, Male	385027	1
15	o o CABLE, 3 Cord, 16 Ga., Bl.	400012	15 ft.
16	o CONNECTOR, Male, 4 Pin	385021	1
	*** ATTACHING PARTS ***		
	o o WASHER, Belville	383000	2
	o o BOLT, Hex, 3/8-16x1-1/2	382503	2
	o o WASHER, 3/8 I.D.	382501	10
	o o SCREW, Set, 1/4-20x1/4 Lg	382005	4

Table 5-9. X-Ray Generator Parts List - Continued

Figure & Index No.	Description	Part Number	Qty Per Unit
5-9 - Continued			
	o o SCREW, Flat, Soc Head, 10-32x1/2	381504	4
	o o SCREW, Flat Head, 6-32x1/2	380507	2
	o o SCREW, Phillips, Pan Head, 8-32x1/2	381004	14
	o o SCREW, Phillips, Pan Head, 10-32x1/2	381505	8
	o o SCREW, Phillips Pan Head, 6-32x3/4	380504	6
	o o SPACER, No. 8-32x.75 Lg.	383508	4
	o o SCREW, Phillips, Flat Head, 8-32x3/8	381009	2
	o o WASHER, Lock, No. 8	381002	14
	o o WASHER, Lock, No. 10	381502	8
	o o WASHER, Lock, No. 6	380502	6

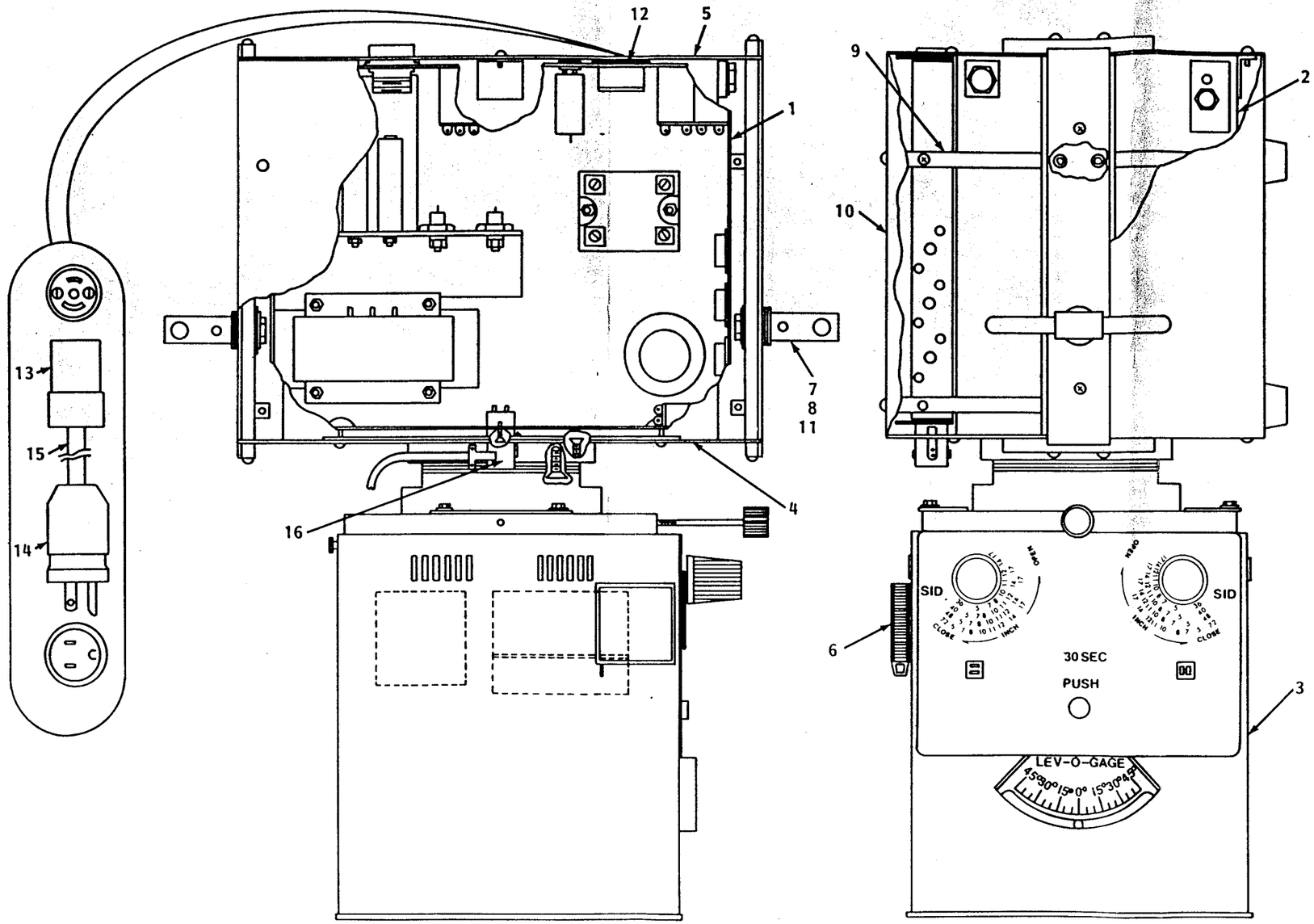


Figure 5-9. X-Ray Generator (P/N 500154)
Location of Components

Table 5-10. X-Ray Generator Chassis Assembly Parts List

Figure & Index No.	Description	Part Number	Qty Per Unit
5-10	CHASSIS ASSEMBLY	500147	1
1	o o CHASSIS	100439	1
2	o o BRACKET	100093	1
3	o o PC BOARD ASSEMBLY, AC to DC (mA Converter)	500152	1
4	o o HARNESS ASSEMBLY	500140	1
5	o o RELAY, 2PDT	378009	3
6	o o RELAY, 3PDT	378006	1
7	o o TRANSFORMER, 120 V	360004	1
8	o o CIRCUIT BREAKER, 10 Amp	378010	1
9	o o LAMP, Red	390002	1
10	o o RESISTOR, w/w, Fixed, 300 ohms, 20W	340041	1
11	o o ZENER DIODE, w/Nuts and Lug ( )	303004	2
12	o o RESISTOR w/w, Fixed, 150 ohms, 25W ( )	340019	1
13	o o RESISTOR, w/w, Fixed, 0.50 ohm, 12W ( )	340039	2
14	o o CONNECTOR, Flanged, Male, AC ( )	385011	1
15	o o PHONE JACKS ( )	385022	1
16	o o CONNECTOR RECEPTACLE, Four-Pin ( )	385014	1
17	o o RELAY, Solid State ( )	378025	1
18	o o CONNECTOR RECEPTACLE ( )	385085	1
19	o o PIN, Socket ( )	385087	11

Table 5-10. X-Ray Generator Chassis Assembly Parts List - Continued

Figure & Index No.	Description	Part Number	Qty Per Unit
5-10 - Continued			
20	o o RESISTOR, Variable, 100 ohm, 3W	345004	3
	*** ATTACHING PARTS ***		
	RIVET, Pop, 1/4 in. Lg	384009	4
	RIVET, Pop, 1/2 in. Lg	384008	10
	WASHER, Shoulder, Nylon	384038	12
	BUSHING, Shoulder, Nylon	383523	8
	SPACER, No. 6x1/4 Lg	383521	2
	SPACER, No. 6x1/8 Lg	383538	2
	SCREW, Pan Head, No. 6-32x1-1/2 Lg	380525	4
	WASHER, Flat, No. 6	380501	6
	WASHER, Lock, Split, No. 6	380502	5
	NUT, Hex, 6-32	380500	6
	WASHER, Shoulder, Nylon	384045	2
	WASHER, Insulating	384069	2
	LUG, Solder Locking, 1/4 in. Lg.	REF SEE 303004 DIODE ZENER	2
	SCREW, Pan Head, No. 8-32x2-1/2 Lg	381003	2
	SCREW, Pan Head, No. 6-32x3/8	380514	2
	SCREW, Pan Head, No. 8-32x1/2	381004	2
	NUT, No. 8	381000	6
	WASHER, Flat, No. 8	381001	10

Table 5-10. X-Ray Generator Chassis Assembly Parts List - Continued

Figure & Index No.	Description	Part Number	Qty Per Unit
5-10 - Continued			
	*** ATTACHING PARTS - Continued ***		
	WASHER, Split, Lock	381002	6
	FASTENER, No. 6-32	383004	2
	WASHER, Lock, Ext. Tooth, No. 6	380528	1
	SCREW, Pan Head, No. 6-32x3/4 in.	380504	1
	SCREW, Pan Head, No. 8-32x2-1/4 Lg	381017	2

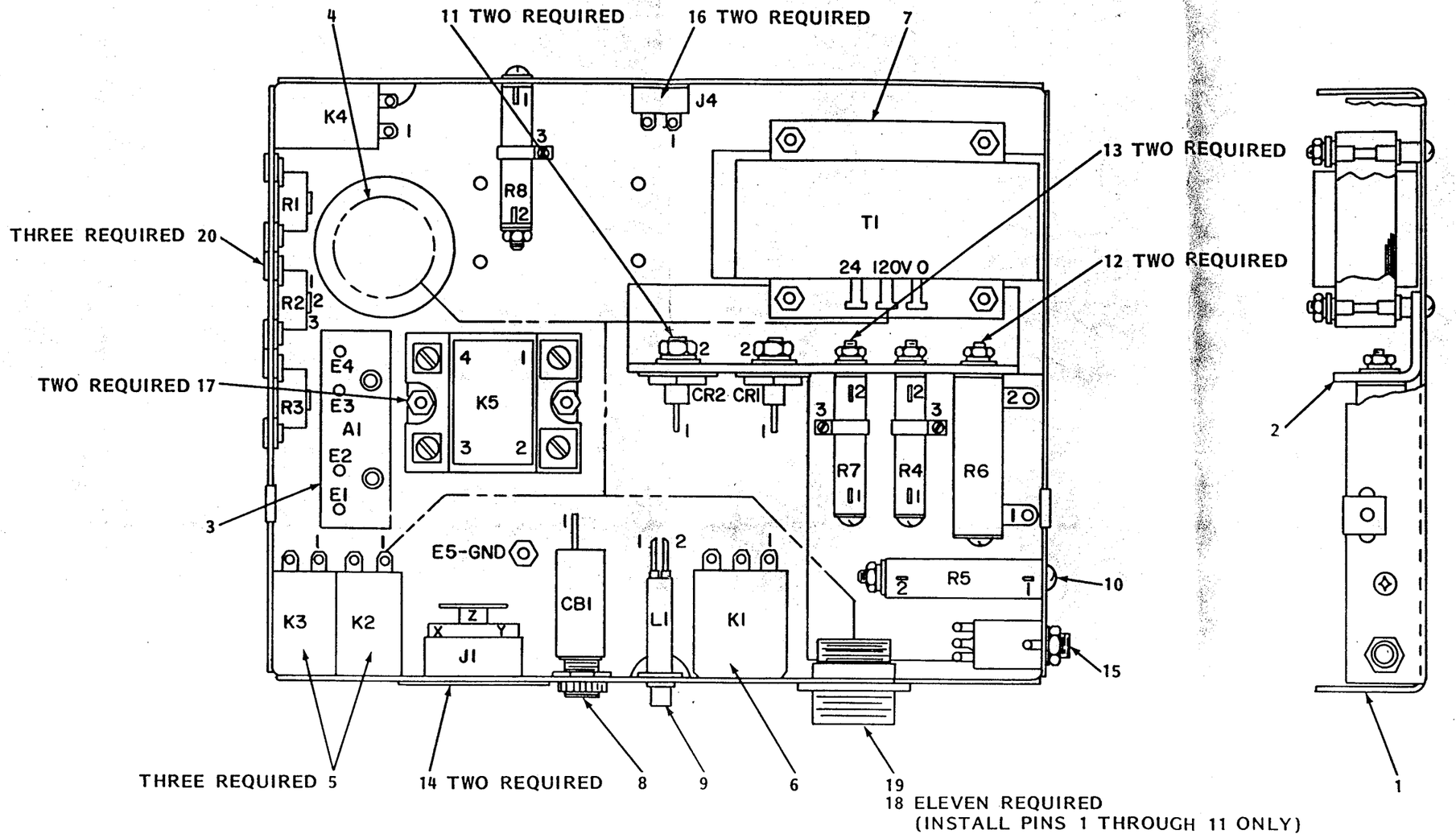


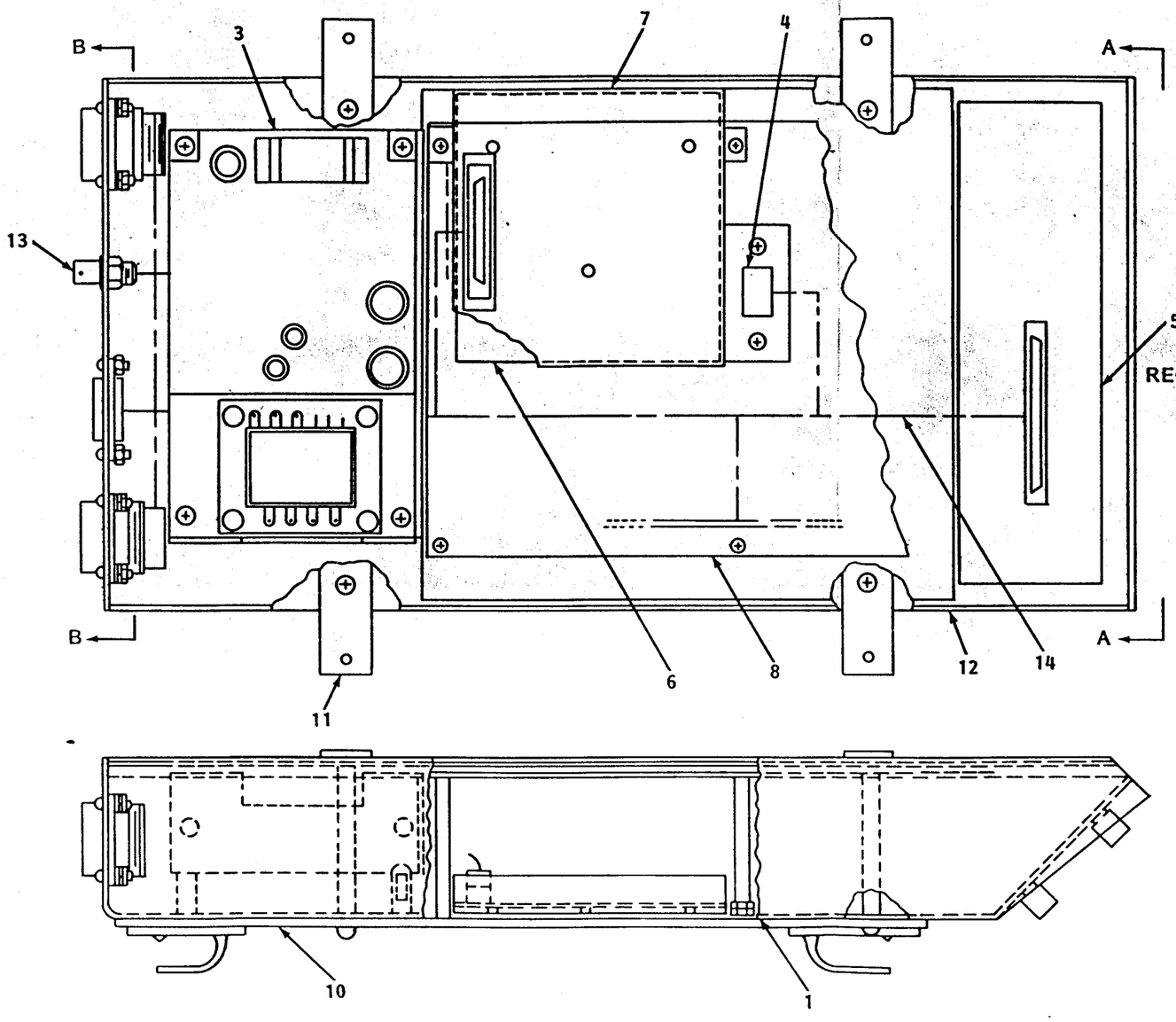
Figure 5-10. X-Ray Generator Chassis Assembly (P/N 500147) Location of Components

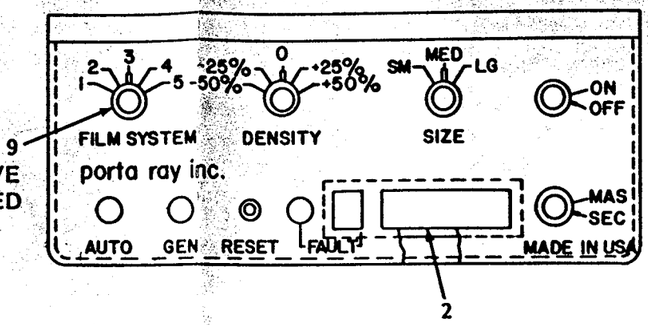
Table 5-11. Automatic Exposure Control (P/N 500225) Parts List

Figure & Index No.	Description	Part Number	Qty Per Unit
5-11	AUTOMATIC EXPOSURE CONTROL 9160	500225	1
1	o CHASSIS	100463	1
2	o RED LENS	100531	1
3	o POWER SUPPLY	390086	1
4	o DIP RELAY, 5 Vdc DPDT	378037	1
5	o PC BOARD ASSEMBLY, Display	500117	1
6	o PC BOARD ASSEMBLY	500169	1
7	o COVER SHIELD	100540	1
8	o PC BOARD ASSEMBLY	500217	1
9	o KNOB	390093	5
10	o MOUNTING PLATE ASSEMBLY	500205	1
11	o MOUNTING PLATE BRACKET	100521	2
12	o COVER PLATE ASSEMBLY	500209	1
13	o CONNECTOR, BNC Receptacle	385035	1
14	o HARNESS ASSEMBLY	500206	1
	*** ATTACHING PARTS ***		
	o o SCREW, Pan Head, 8-32x3/4 Lg	381030	4
	o o SCREW, Flat Head, 8-32x1/4 Lg	381010	9
	o o SPACER, 8-32x2-3/8 Lg	383530	4
	o o SPACER, 4-40x2 Lg	383529	4
	o o WASHER, Lock, No. 4	380002	14

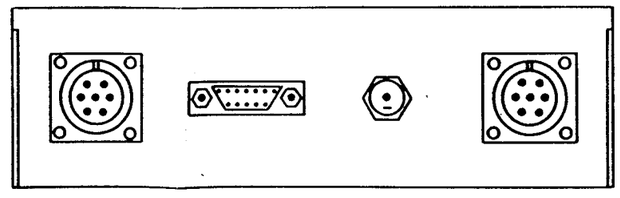
Table 5-11. Automatic Exposure Control (P/N 500225) Parts List - Continued

Figure & Index No.	Description	Part Number	Qty Per Unit
5-11 - Continued			
	o o SCREW, Phillips, Pan Head 4-40x1/2	380008	10
	o o WASHER, Flat, No. 4	380001	10
	o o NUT, 4-40	380000	10
	o o SCREW, Pan Head, 8-32x3/8 Lg	381006	4
	o o WASHER, Flat, No. 8	381001	8
	o o WASHER, Lock, No. 8	381002	8





VIEW A-A



VIEW B-B
WIRING SIDE

Figure 5-11. Automatic Exposure Control (P/N 500225) Location of Components

Table 5-12. Line Power Controller (P/N 500258) Parts List

Figure & Index No.	Description	Part Number	Qty Per Unit
5-12	LINE POWER CONTROLLER	500258	1
1	o PANEL	100634	1
2	o COVER	100635	1
3	o CIRCUIT BREAKER, 5A (CB1)	378001	1
4	o CIRCUIT BREAKER, 10A (CB2)	378010	1
5	o METER (M1)	374004	1
6	o SWITCH, Rocker, DPST (S1)	370018	1
7	o RELAY, 3PDT (K1)	378036	1
8	o SWITCH, Rotary (S2)	370024	1
9	o CONNECTOR, Male (J1)	385011	1
10	o TRANSFORMER, Auto (T1)	360033	1
11	o CONNECTOR, Female (J2)	385125	1
12	o KNOB, Plain	390060	1
13	o LINE SENSE, Printed Circuit Board Assembly (A1)	500259	1
	*** ATTACHING PARTS ***		
	o o SCREW, Pan Head, No. 6-32x3/8	380514	4
	o o SCREW, Pan Head, No. 8-32x1/2	381004	10
	o o SCREW, Pan Head, No. 10-32x1/2	381513	4
	o o WASHER, Flat, No. 6	MS15795-805	4
	o o WASHER, Flat, No. 8	MS15795-807	10
	o o WASHER, Flat, No. 10	MS15795-808	4

Table 5-12. Line Power Controller (P/N 500258) Parts List - Continued

Figure & Index No.	Description	Part Number	Qty Per Unit
	o o WASHER, Lock, No. 6	MS35338-136	4
	o o WASHER, Lock, No. 8	MS35338-137	10
	o o WASHER, Lock, No. 10	MS35338-138	4
	o o NUT, Plain, No. 8-32	381500	4
	o o NUT, Plain, No. 10-32	381000	4

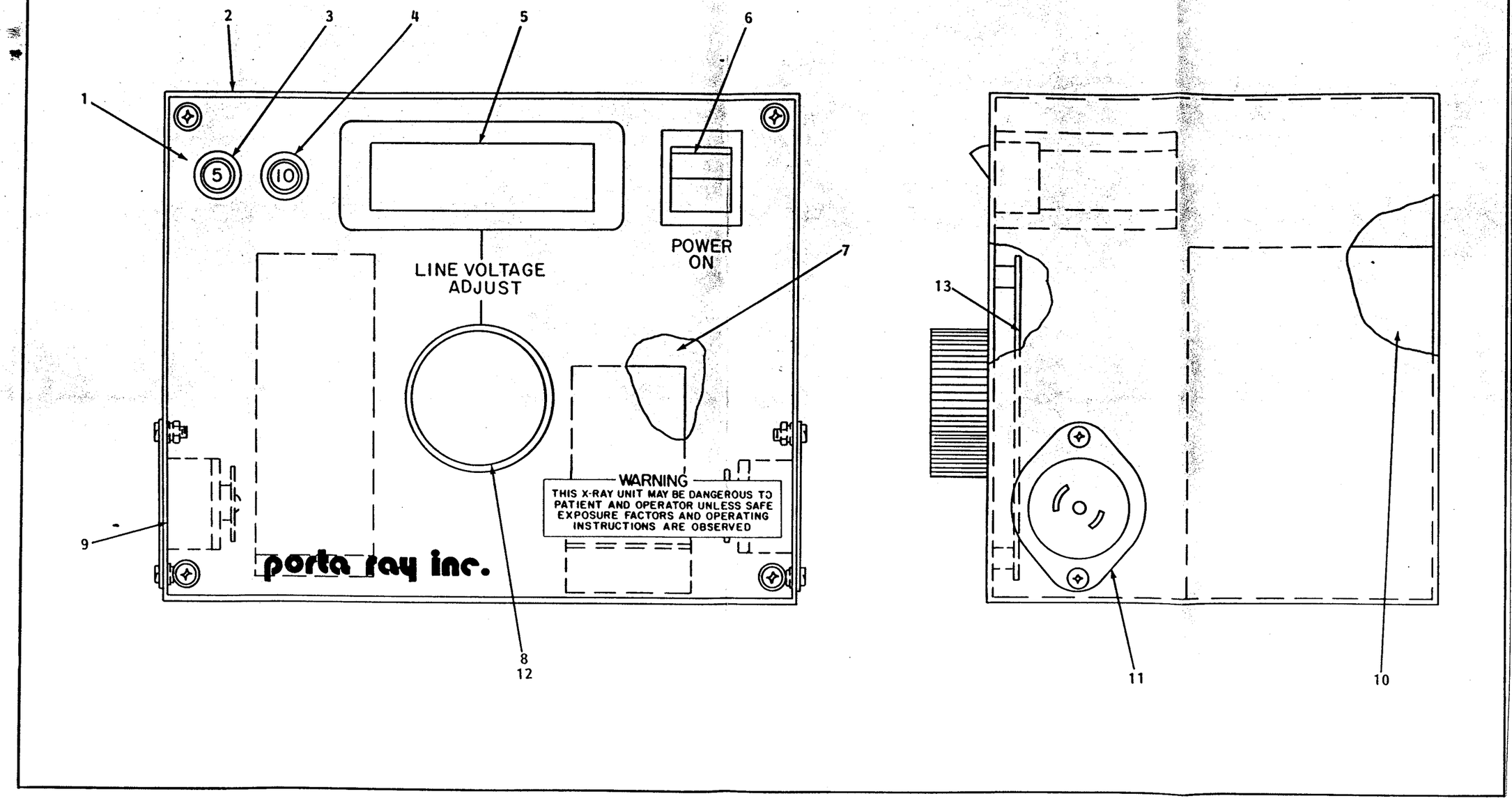


Figure 5-12. Line Power Controller (P/N 500258) Location of Components

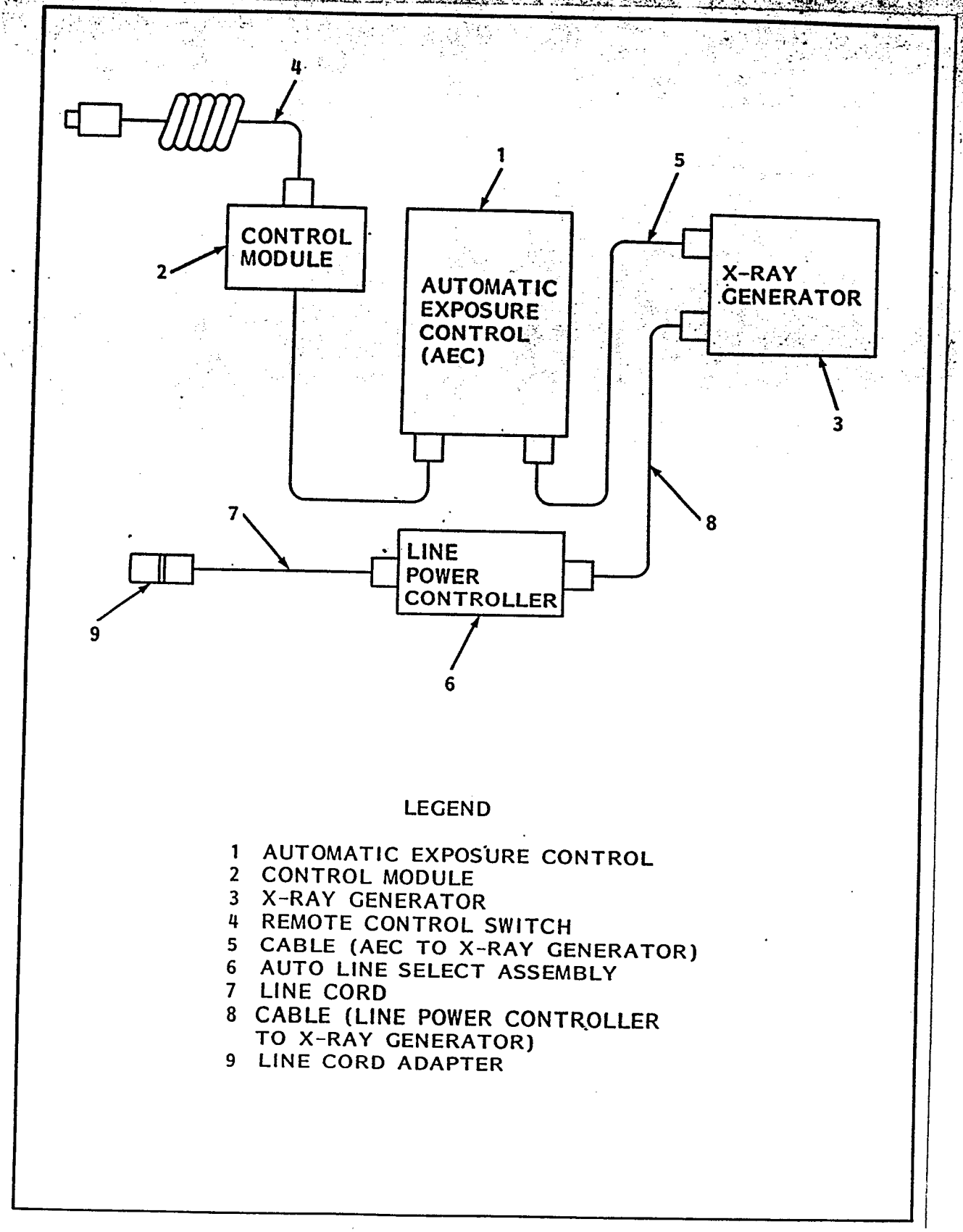
SECTION 6
DIAGRAMS

6-1. INTRODUCTION

This section contains the Porta Ray electrical drawings required to maintain the Model 9160M X-Ray System. Table 6-1 is a figure number vs. Porta Ray drawings list for the drawings in this section.

Table 6-1. Porta Ray Drawing Number vs. Figure Number

Porta Ray Drawing No.	Manual Figure No.	Title
500252	6-1	X-Ray System, Interconnecting Cable Diagram
700041	6-2	Control Module (P/N 500151) Schematic Diagram
700039	6-3	Control Module 1160 Timer PC Board Assembly A1 (P/N 500140) Schematic Diagram
700058	6-4	AC to DC Ma Converter PC Board Assembly A2 (P/N 500152) Schematic Diagram
700059	6-5	Automatic Exposure Control Assembly Schematic Diagram
700032	6-6	Display Printed Circuit Board Assembly A1 (P/N 500117) Schematic Diagram
700056	6-7	Photo Timer Printed Circuit Board Assembly A2 (P/N 500217) Schematic Diagram (4 sheets)
700045	6-8	Pre Amp Detector Printed Circuit Board Assembly A3 (P/N 500169) Schematic Diagram
700040	6-9	X-Ray Generator, Chassis Assembly (P/N 500147) Schematic Diagram
--	6-10	Collimator Wiring Diagram
--	6-11	Line Power Controller (P/N 500258) Schematic Diagram
--	6-12	Line Power Controller PC Board (P/N 500) Schematic Diagram



LEGEND

1 AUTOMATIC EXPOSURE CONTROL
2 CONTROL MODULE
3 X-RAY GENERATOR
4 REMOTE CONTROL SWITCH
5 CABLE (AEC TO X-RAY GENERATOR)
6 AUTO LINE SELECT ASSEMBLY
7 LINE CORD
8 CABLE (LINE POWER CONTROLLER TO X-RAY GENERATOR)
9 LINE CORD ADAPTER

Figure 6-1. X-Ray System, Interconnecting Cable Diagram

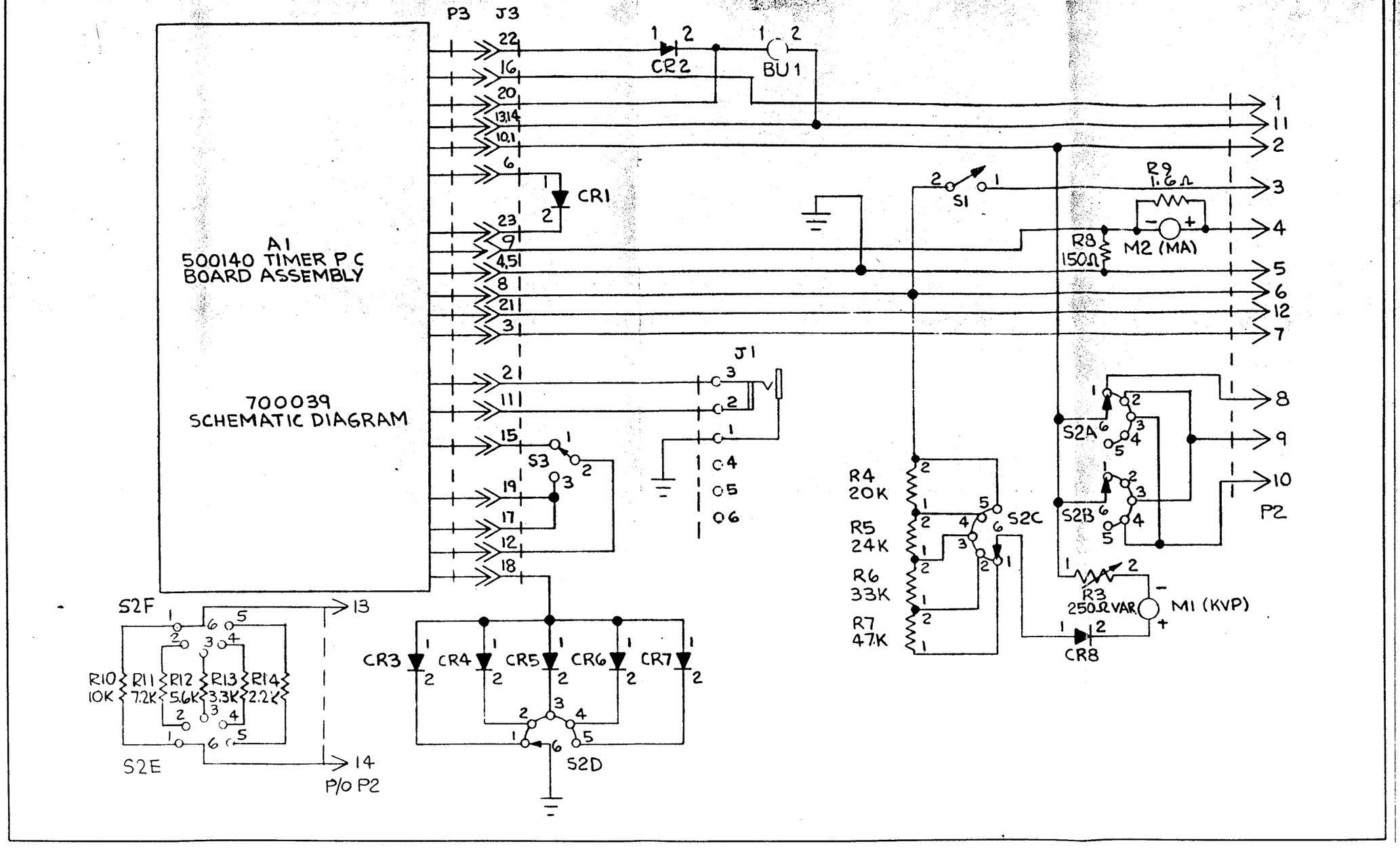


Figure 6-2. Control Module (P/N 500151) Schematic Diagram

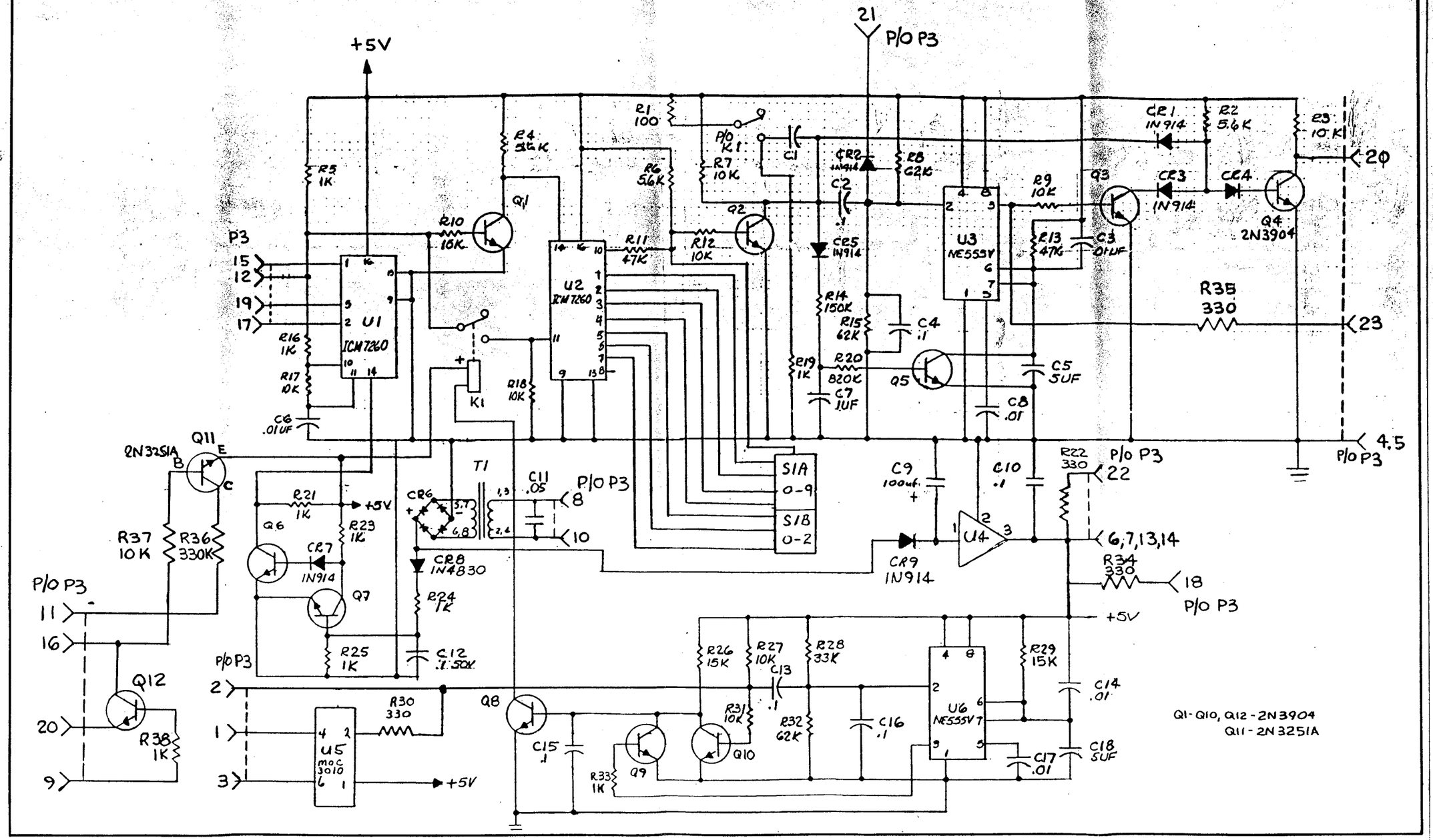


Figure 6-3. Control Module 1160 Timer PC Board Assembly A1 (P/N 500140) Schematic Diagram

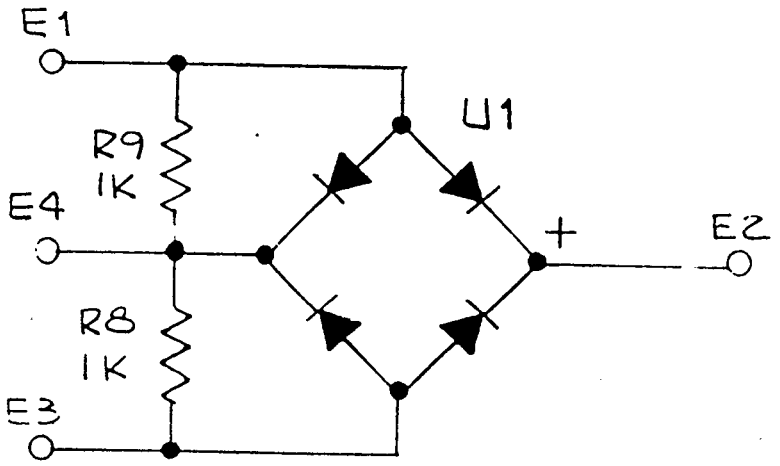


Figure 6-4. AC to DC Ma Converter PC Board Assembly A2 (P/N 500152) Schematic Diagram

NOTE!
1. ALL RESISTORS ARE 1/4 WATT UNLESS OTHERWISE NOTED.

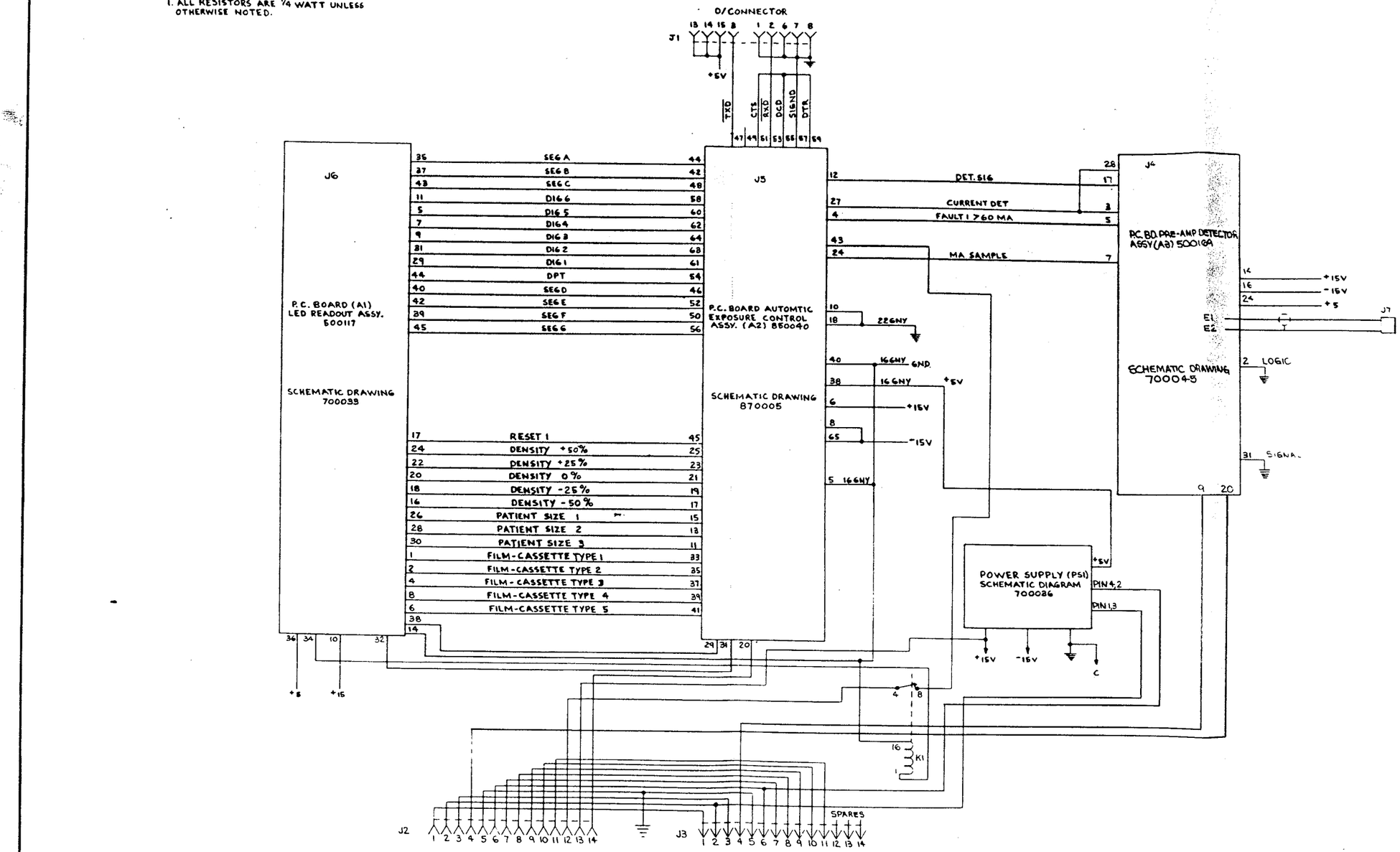


Figure 6-5. Automatic Exposure Control Assembly Schematic Diagram

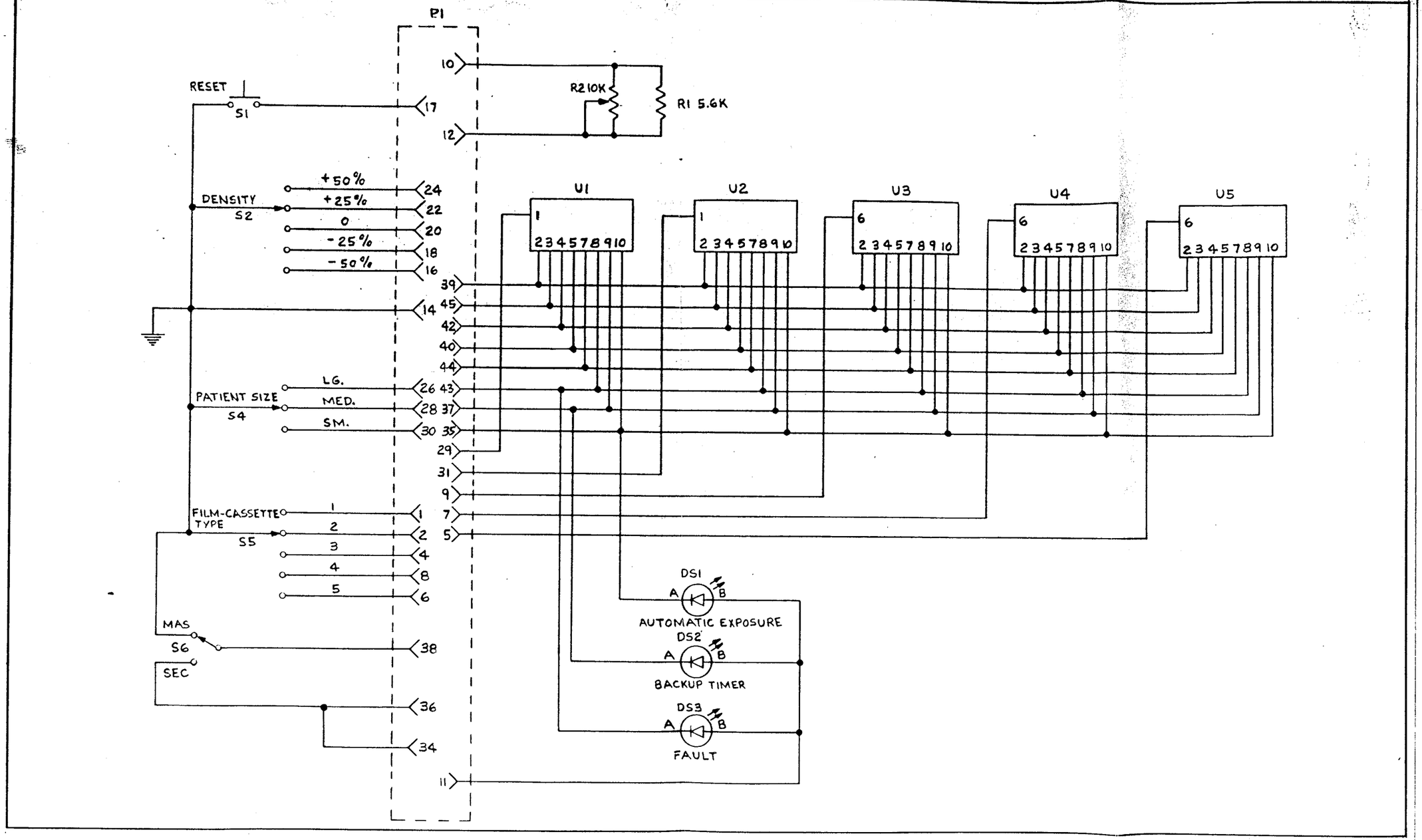


Figure 6-6. Display Printed Circuit Board Assembly A1 (P/N 500117) Schematic Diagram

NOTES: (UNLESS OTHERWISE SPECIFIED)

1. PARTIAL REF. DESIG. ARE SHOWN. FOR COMPLETE DESIG., PREFIX WITH UNIT NUMBER OR SUB-ASSY DESIG.
2. RESISTOR VALUES ARE IN OHMS ±5% ¼W.
3. CAPACITANCE VALUES ARE IN MICROFARADS.
4. U1 = 74LS14
   U2 = 7406
   U3 = 74LS00
   U4 = 74LS04
   U5 = 74LS10

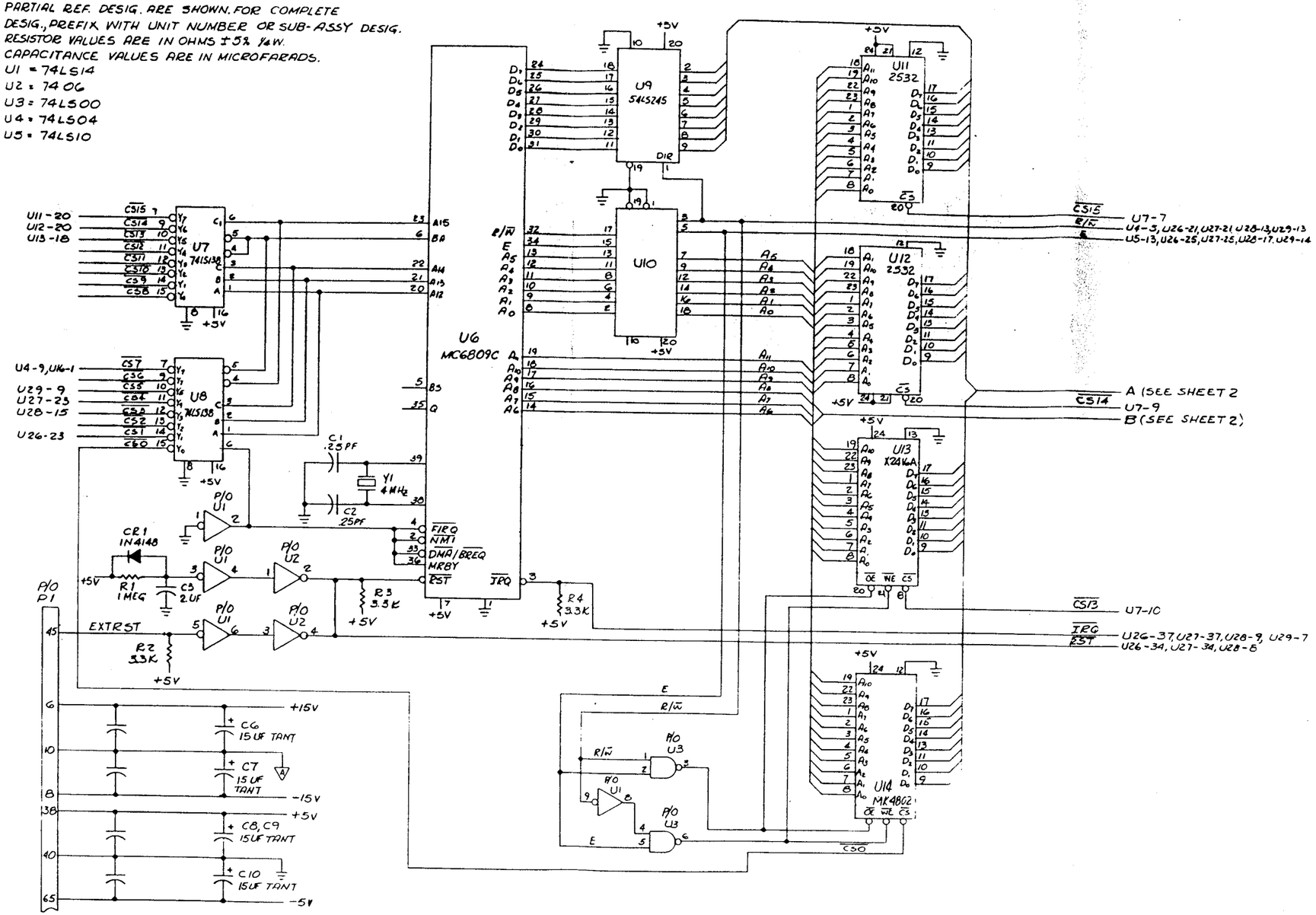


Figure 6-7. Photo Timer Printed Circuit Board Assembly A2 (P/N 500217) Schematic Diagram (Sheet 1 of 4)

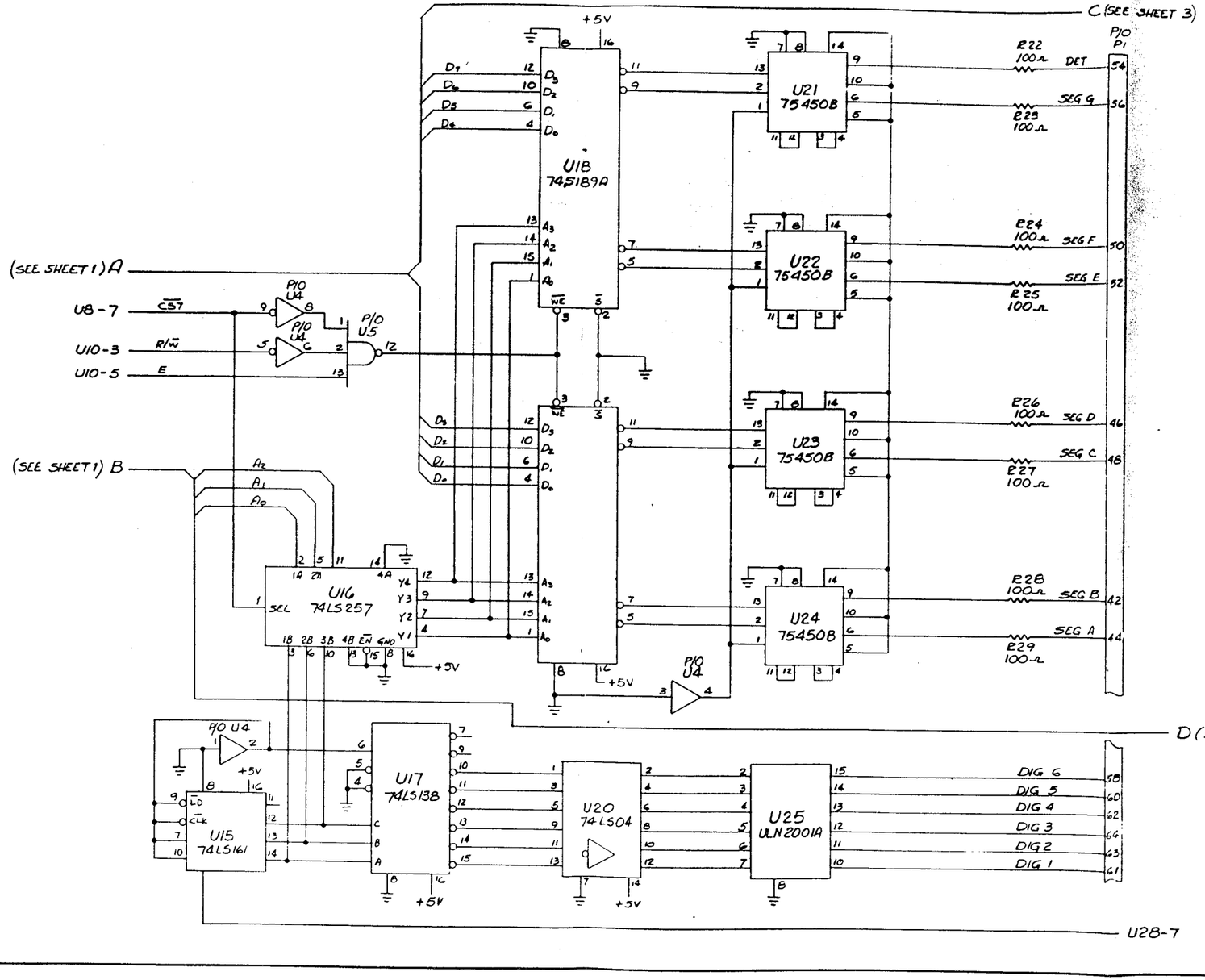


Figure 6-7. Photo Timer Printed Circuit Board Assembly A2 (P/N 500217) Schematic Diagram (Sheet 2 of 4)

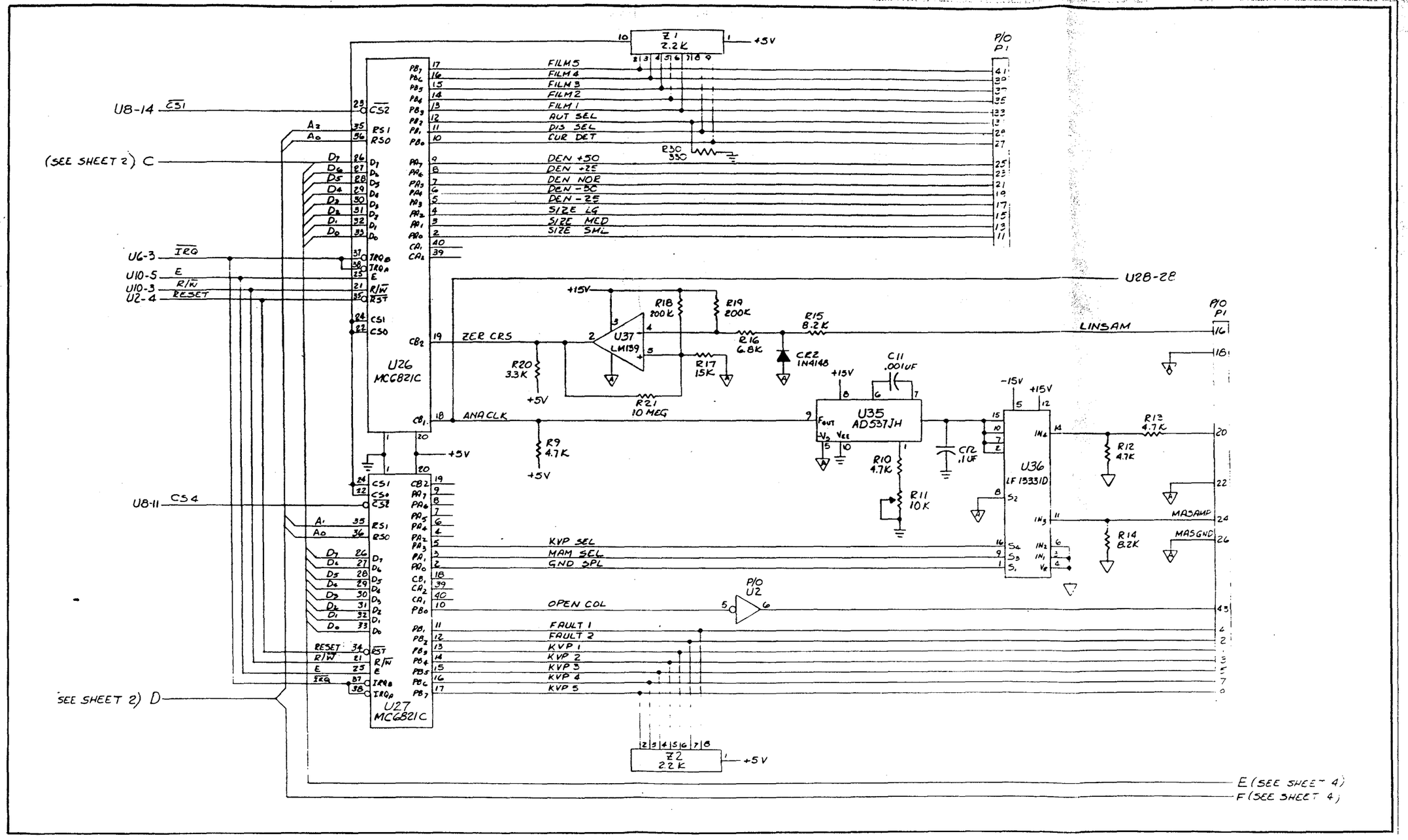


Figure 6-7. Photo Timer Printed Circuit Board Assembly A2 (P/N 500217) Schematic Diagram (Sheet 3 of 4)

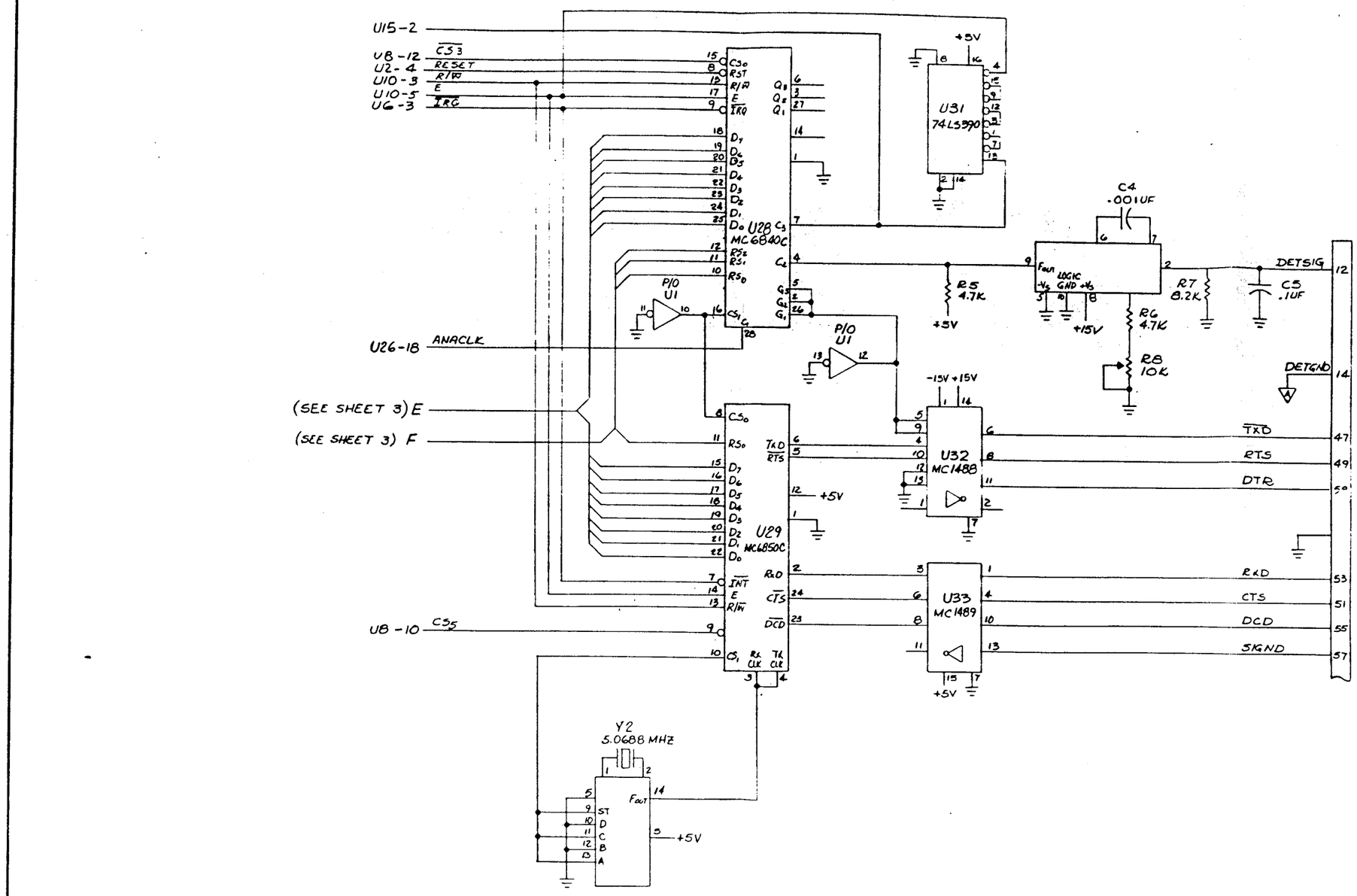


Figure 6-7. Photo Timer Printed Circuit Board Assembly A2 (P/N 500217) Schematic Diagram (Sheet 4 of 4)

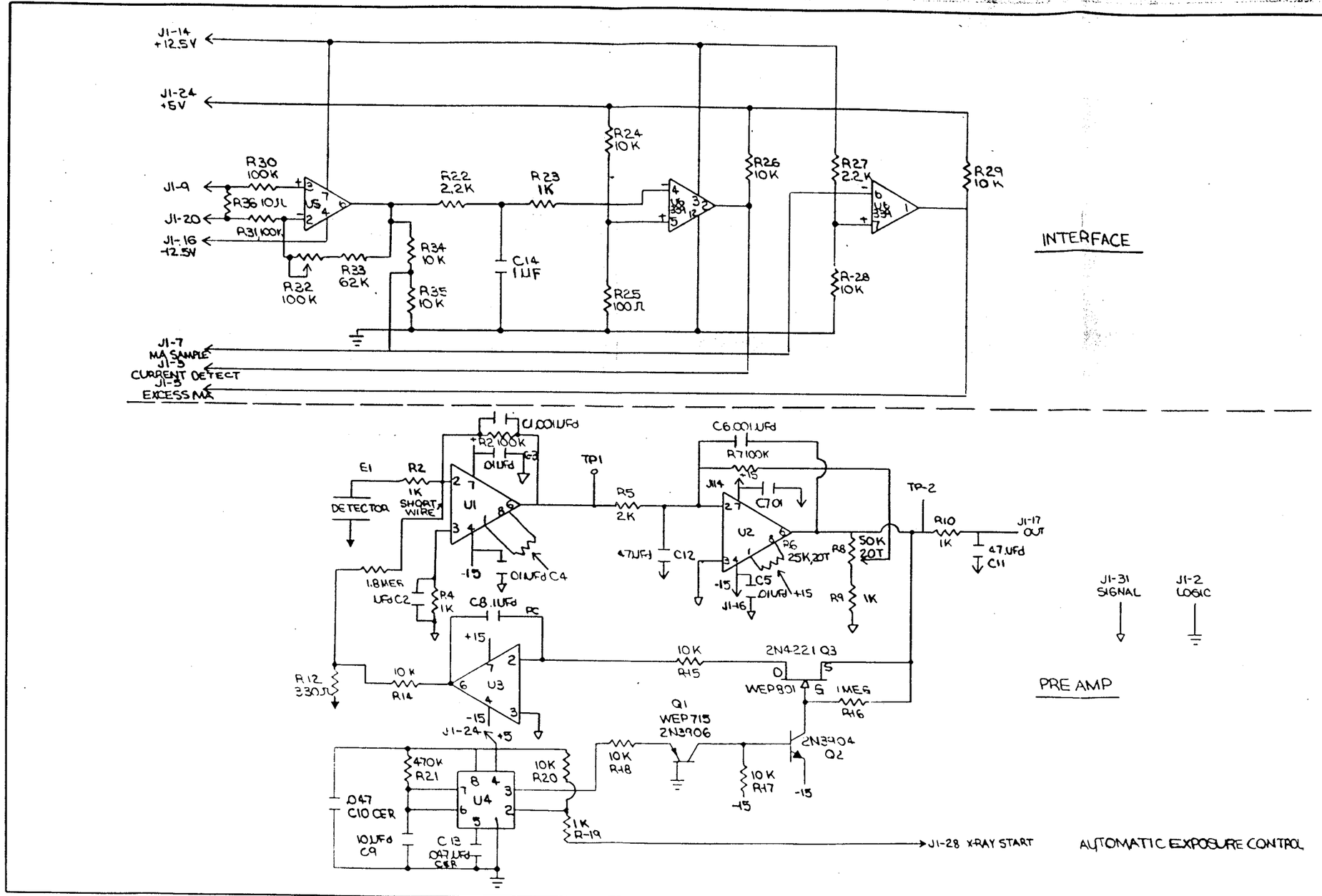


Figure 6-8. Pre Amp Detector Printed Circuit Board Assembly A3 (P/N 500169) Schematic Diagram

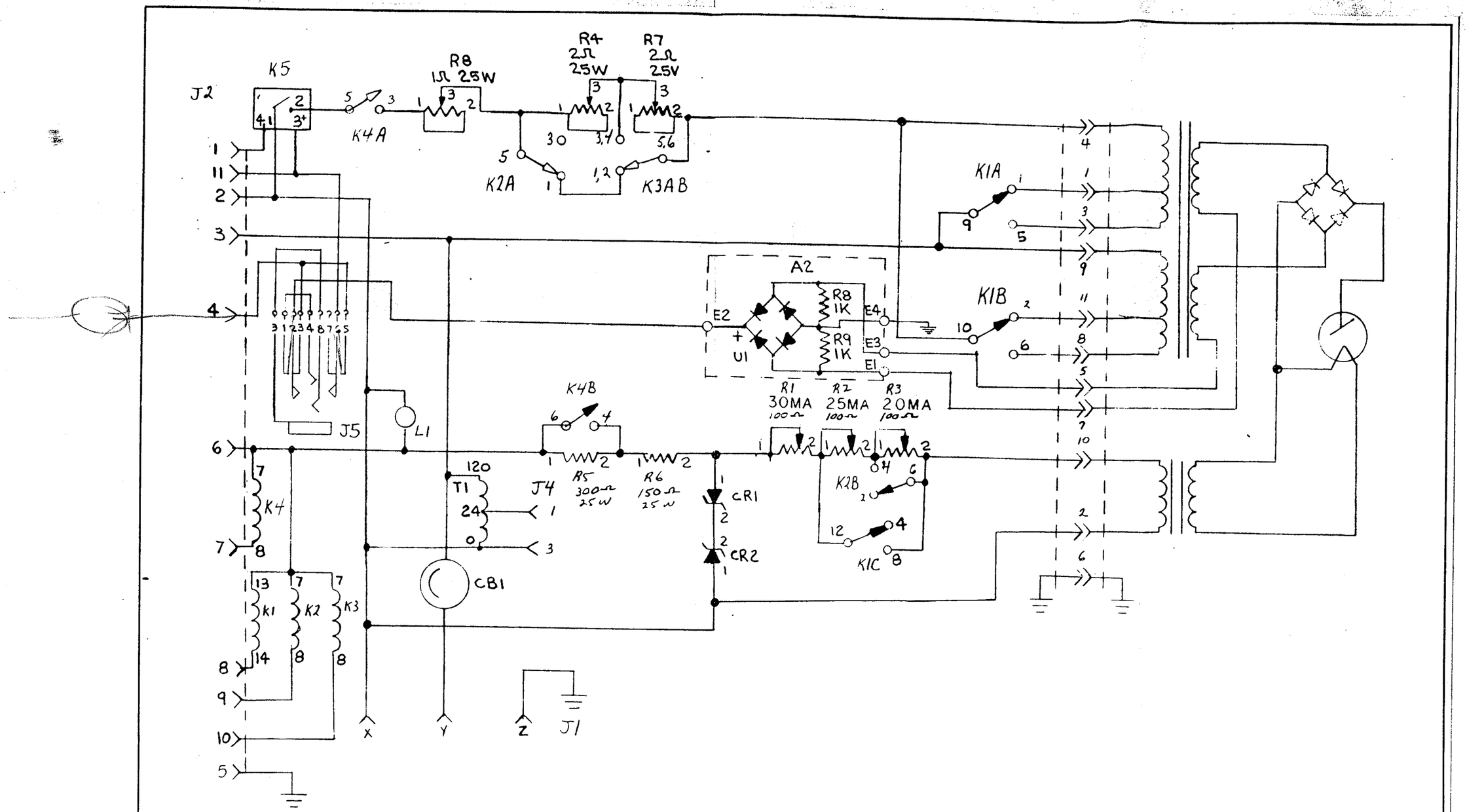


Figure 6-9. X-Ray Generator, Chassis Assembly (P/N 500147) Schematic Diagram

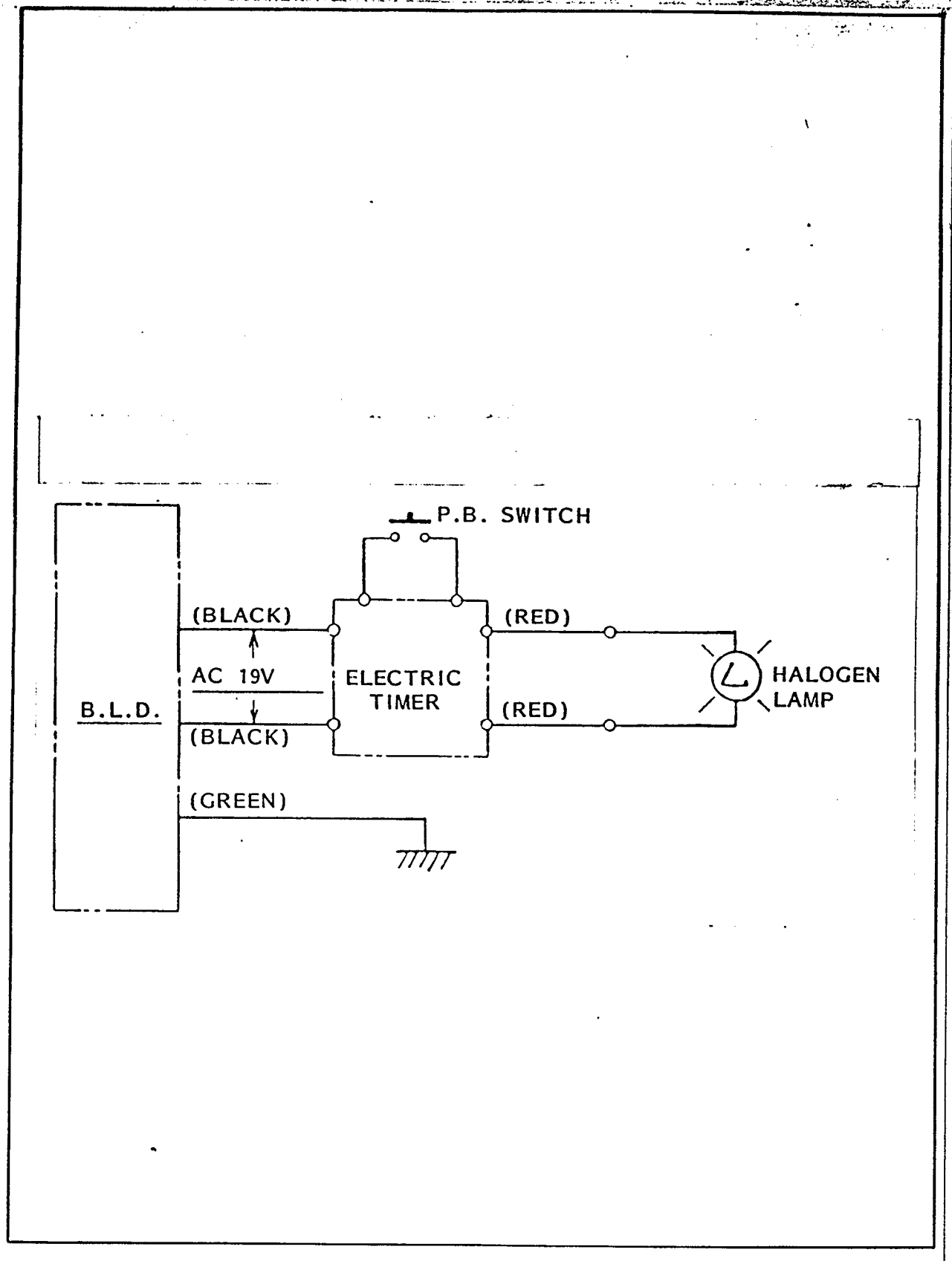


Figure 6-10. Collimator Wiring Diagram

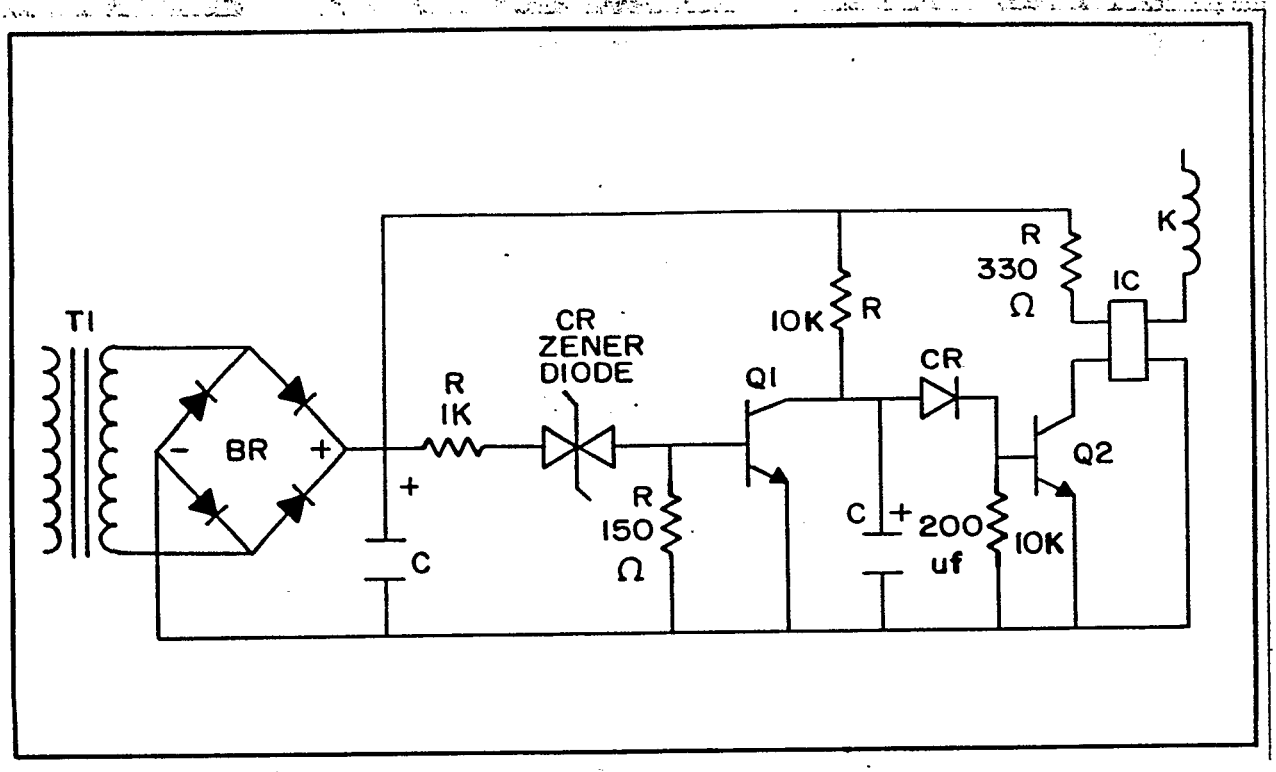


Figure 6-11. Line Power Controller, Schematic Diagram

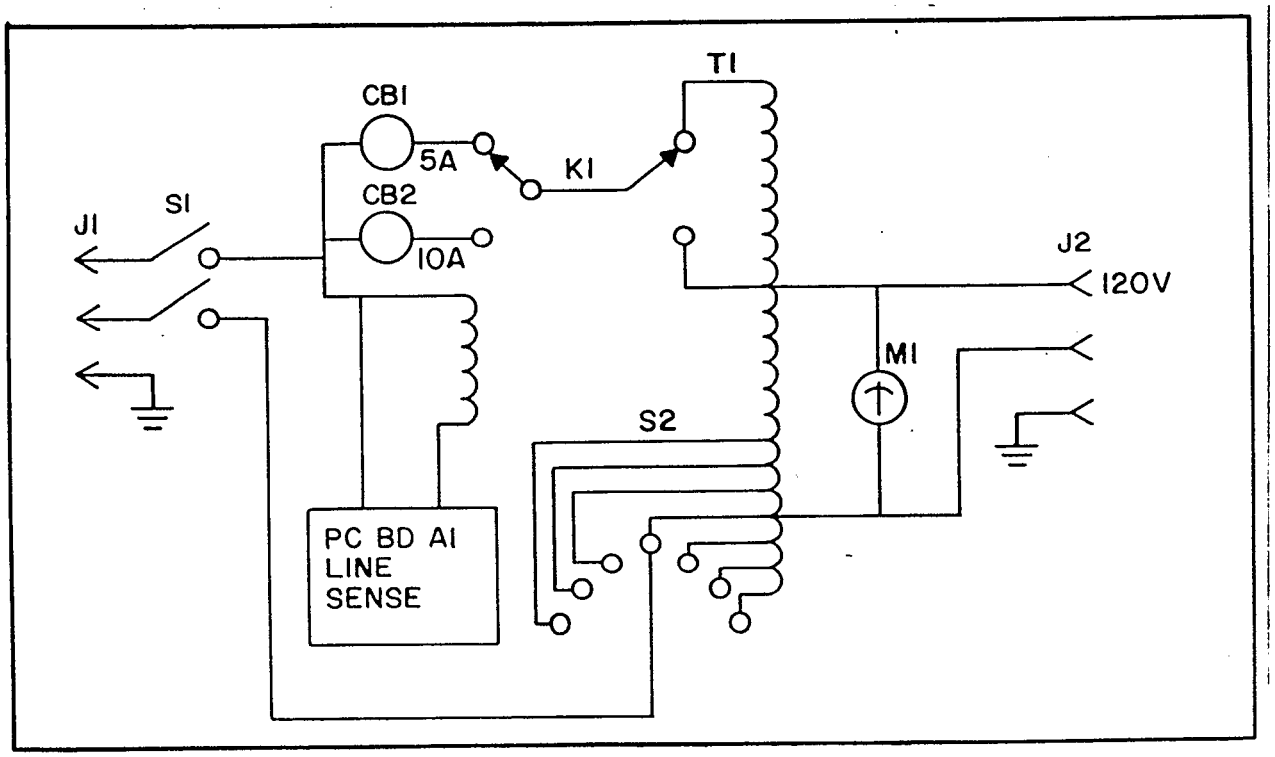


Figure 6-12. Line Power Controller PC Board Assembly A1, Schematic Diagram

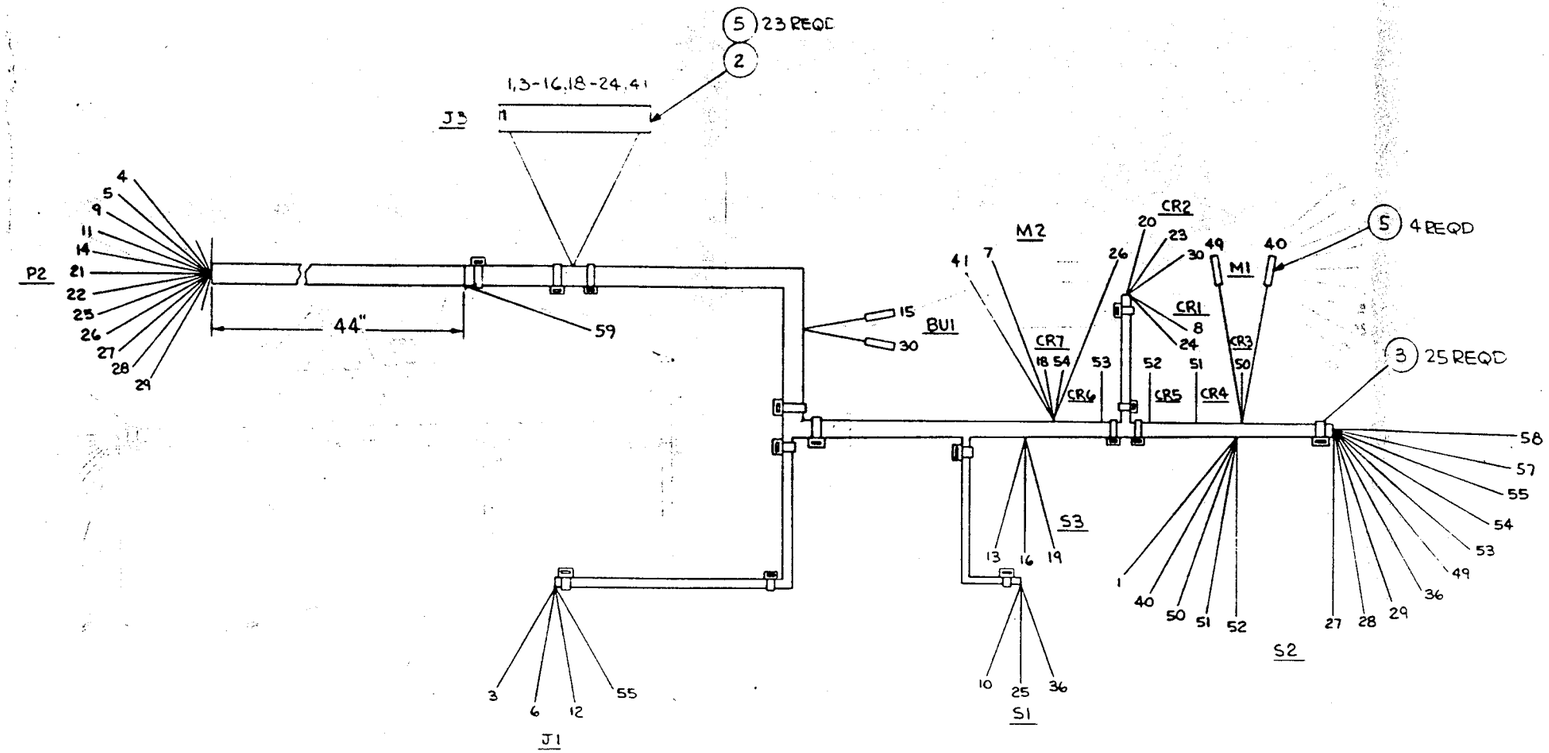


Figure 6-13. Harness Assembly (P/N 500164) Schematic Diagram